# AN ANALYSIS OF AGRICULTURAL PRODUCTION IN MEXICO, 1969-1979, AND COMPARISONS WITH THE UNITED STATES.

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# AN ANALYSIS OF AGRICULTURAL PRODUCTION IN MEXICO, 1969-1979, AND COMPARISONS WITH THE UNITED STATES

by

Roberto Fernando Salmon-Castelo

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DEPARTMENT OF AGRICULTURAL ECONOMICS

In Partial Fulfillment of the Requirements
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## APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Roger W. Fox
ROGER W. FOX
Professor of Agricultural Economics

June 30, 1982
Date

To my parents, Roberto and Lilian,

To my parents-in-law, Enrique and Ana Graciela, and

To my wife Lorenia, my daughter Ana Lorenia, and my son Roberto Fernando.

## ACKNOWLEDGMENTS

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# ABSTRACT

Land, agricultural labor, fertilizer, and machinery are the selected inputs to Mexican agriculture in which the analysis of this thesis is centered. The period of analysis covers the decade of the seventies, although data from the sixties and eighties are sometimes included. A generalized description of Mexico, the state of Sonora, and the Yaqui Valley as well as a historical view of events that affected latter agricultural development in Mexico are included.

The use and productivity of selected inputs are analyzed at the national, state, and local levels. During the analysis of Mexican agriculture, cross references are made, when applicable, with respect to agricultural production in the United States.

Results show that on the average, Mexican agriculture makes use of modern inputs of production but is still in a developing stage. Future governmental policies regarding agricultural production will tend to concentrate more on rainfed producing areas rather than on irrigated areas.

# CHAPTER 1

## INTRODUCTION

This thesis analyzes and measures the agricultural production of Mexico. Although the focus is on recent agricultural production, namely that of the decade of the seventies, data from the decade of the sixties are also included for purposes of a more adequate statistical analysis. A historical review, dating since the prerevolutionary period, gives an insight into major policy development regarding agriculture in Mexico. The analysis will take place at the national level, and at the state and local levels. The national level includes an aggregate analysis of agricultural production from the state of Sonora, and the local level focuses on production from the Yaqui Valley, in the state of Sonora. The analysis of production centers around the use of selected inputs used in production. The selection of these inputs was based on their importance in production and their measurability.

Agricultural production figures for each level were readily available. For the national level, agricultural production indices from the Food and Agricultural Organization (F.A.O.) of the United Nations were used; for the state and local levels, raw production data were transformed into indices of agricultural production. Inputs used in the production process at the national level were obtained mainly from F.A.O. publications. For the state and local levels data came mostly from the Ministry of Agriculture and Water Resources (SARH).

The differences in the types of data obtained for the national level compared to those obtained for the state and local levels resulted in different types of analyses. Whereas for the national level the emphasis of the analysis was placed more on the productivity of inputs, at the state and local levels quantitative and qualitative approaches, different from those used on the national level, were taken.

It was intended during the analysis of agricultural production of Mexico to make cross references to agricultural production of the United States at the three levels of production proposed. The reason for making such references is mainly because of the levels of development of agriculture in the United States, Arizona, and Pinal County, which serve for purposes of comparison between the two countries, the two states, and the two local areas.

# CHAPTER 2

# GENERAL DESCRIPTION OF AGRICULTURE IN MEXICO

## Location, Topography, and Climate

Mexico is located between 14°33' and 32°43' latitude north, and between 86°46' and 117°08' longitude west. It borders the north with the United States of America on 2,597 kilometers and to the south with Guatemala and Belize on 1,133 kilometers. To the west there is the Pacific Ocean on 6,608 kilometers of sea shore and to the east the Gulf of Mexico and 2,611 kilometers of coasts. Approximately half of the country is situated in the tropical zone to the south of the Tropic of Cancer Line located at 23°72' latitude north.

The total area of Mexico is 1,969,269 square kilometers, which includes 5,379 square kilometers of islands. Most of the country is mountainous, and the most important mountain ranges are the Sierra Madre Oriental, which extends from Oaxaca to Texas, and the Sierra Madre Occidental, which extends along the Pacific Coast.

From the total area of the country, 52% can be considered arid, 31% semi-arid, 11% semi-humid, and 7% as humid. See Figure 1 for reference. The arid zones are considered as those zones in which agriculture can exist only if irrigation is provided. Semi-arid zones are those areas where there are years with insufficient rain and years with abundant rain although badly distributed; in these areas, irrigation must be used to complement rainfall. Semi-humid zones are those in which 50%

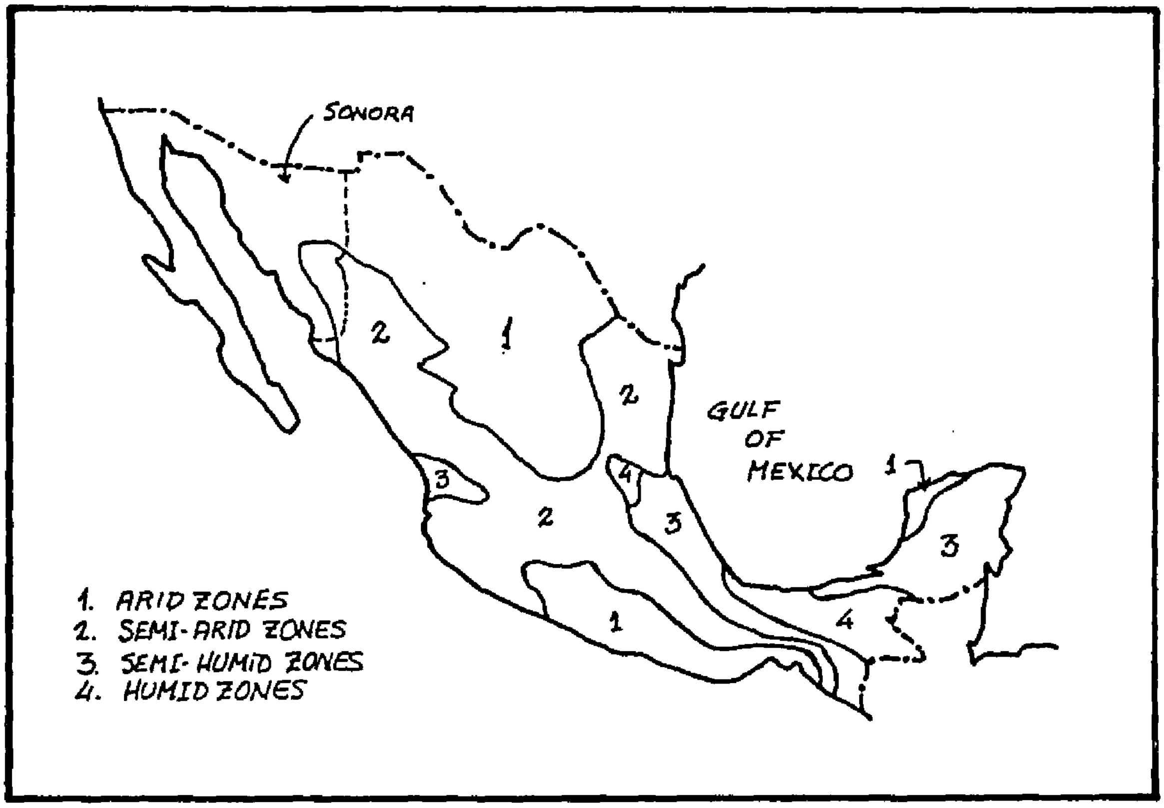


Figure 1. Climatic zones of Mexico.
(Modified after Navarrete, 1971.)

of the time rainfall is sufficient to obtain crops without irrigation, but the remaining 50% of the time irrigation is necessary. Finally, humid zones are those in which rainfall is adequate and well distributed to satisfy crop needs; however, in Mexico, lands in these areas, for the most part, need improved drainage (Navarrete 1971).

From this information we can see that the climate of Mexico, especially with respect to rainfall, is not adequate for agriculture without making some investment in irrigation and drainage. Furthermore, the mountainous topography of the country becomes a restriction to the extensive use of agriculture and irrigation.

## Agricultural Regions of Mexico

### North and South Division

Agriculture has reached different stages of progress in Mexico's various regions. These different stages of progress have been emerging since 1940. Roughly, the northern part of the country is more advanced agriculturally than the southern part.

The south is in the torrid zone; mountainous topography and primitive agriculture distinguish this zone. Hertford, referring to the south, says that there are "...limited areas suited for agriculture, [and that] many farmers cultivate corn on badly eroded slopes....Life is rural and agriculture continues for the most part in its traditional form" (Hertford 1970, p. 90; my brackets).

In the north, above the torrid zone, there are fertile valleys where agriculture is modern and for the most part commercially oriented. In this northern part, agriculture must rely heavily on irrigation.

Hertford comments on these regions, saying that "...over most of this region, annual rainfall is less than 20 inches a year [and]...crop production is nearly impossible on these vast stretches of land without irrigation" (Hertford 1970, p. 90; my brackets).

According to data on the value of crops for the agricultural year of 1978, published by Mexico's Department of Agricultural Economics (DGEA), Ministry of Agriculture and Water Resources (SARH), the states that accounted for the greatest share of the value of production were Sinaloa with 24%, Sonora with 20%, Michoacan 7%, Guanajuato 7%, Baja California Norte 6%, Tamaulipas 6%, and Chihuahua 4%. With the exception of Michoacan and Guanajuato, which are southern states, 60% of the value of crop production was shared by only five northern states.

Census Division

The federal government has divided Mexico into eight regions for its census. This division of agricultural regions will be used for our analysis. The Northwest region includes the states of Baja California Norte, Baja California Sur, Sonora, Sinaloa, and Nayarit. The North region includes the states of Chihuahua, Durango, and Coahuila. The states of Nuevo Leon and Tamaulipas are included in the Northeast region. In the North-center we find the states of Zacatecas, Aguascalientes, and San Luis Potosi. The West-center includes Jalisco, Guanajuato, Queretaro, Colima, Michoacan, and Guerrero. In the Center region the states of Hidalgo, Mexico, Distrito Federal, Tlaxcala, Morelos, and Puebla are included. The Gulf-South region includes Veracruz, Tabasco, Oaxaca, and Chiapas. Finally, the Peninsula region includes Campeche, Yucatan, and Quintana Roo. All of these regions and states are shown in Figure 2.

Considering the Northwest (NW), North (N), Northeast (NE), and North-Center (NC) as the northern part of Mexico, and the West-Center (WC), Center (C), Gulf-South (GS), and Peninsula (P) as the south, some comparisons can be derived from this division. Table 1 shows, for 1978, comparisons with respect to the value of production shared by the north and that shared by the south. It also includes the area under irrigation, in percentages, and the rainfed area shared by these two regions.

Table 1. Value of Production, Irrigated Area, and Rainfed Area, North and South Mexico, 1978

| | Percent of total value of production | | Percent of total irrigated area | | Percent of total rainfed area | |
|---|---|---|---|---|---|---|
| North | 72.1 | | 75.4 | | 48.6 | |
| NW | | 53.5 | | 50.4 | | 21.3 |
| N | | 11.3 | | 9.4 | | 0.2 |
| NE | | 6.5 | | 14.5 | | 25.5 |
| NC | | 0.8 | | 1.1 | | 1.6 |
| South | 27.9 | | 24.6 | | 51.4 | |
| WC | | 18.4 | | 16.9 | | 31.3 |
| C | | 6.6 | | 5.7 | | 2.1 |
| GS | | 2.7 | | 1.7 | | 17.8 |
| P | | 0.2 | | 0.3 | | 0.2 |

Source: SARH, DGEA, Anuario Estadistico de la Produccion Agricola de los Estados Unidos Mexicanos, 1978.

Although the data presented in Table 1 are for irrigation districts only, irrigation districts are, nevertheless, important in Mexican agriculture. In 1978, irrigation districts shared 31% of the total value of production with only 19% of the total area harvested.


Figure 2. Map of Mexico.

Data for one year are insufficient to draw any conclusions about trends; they are presented here to illustrate the point that there exist tremendous differences among the various agricultural regions. Thus, when we analyze aggregate agricultural production in Mexico, we must keep in mind these differences (Yates 1981).

## Agriculture in Mexico, Historical Perspective

Agriculture in Mexico has developed at different rates at different points in time. From previous studies on the development of agriculture in Mexico, and from official statistics, agriculture in Mexico can be divided into three main periods: the pre-1940 period, the period between 1940 and 1965, and the post-1965 period.

Relevant events for the first two periods will be mentioned and placed into a framework so that events that influenced and shaped the present policies and status of Mexican agriculture are properly underlined.

### Pre-1940 Period

During this period, the bases for future agricultural development were set. Before 1910, large land-holdings were accumulated in a few hands. As an example of large land-holders, from the years before 1910, we can cite the Terrazas family, from the state of Chihuahua, who owned 2,679,957 hectares. For the most part, these owners of large amounts of land (latifundistas) kept land barren and held to it only as a symbol of status. It is easy to understand that the management of these vast areas of land was a cumbersome task during that period, therefore yielding a low productivity (Carpizo 1969).

This situation of large latifundios started to create an unhappy political climate, especially among peasants. By the period just before 1910, unhappiness could be found everywhere, eventually leading to a revolution which started in 1910.

Previous constitutions and legislations had tried, but failed, to prevent accumulation of land in the hands of a few, and so created the situation that prevailed during the last decade of the 19th century and first of the 20th century. During the debates that led to the Constitution of 1857, Ponciano Arriaga, a constituent, addressed the Congress in June of 1856, saying:

> There are landholders that occupy...a land area greater than the area occupied by some of our states...even greater than the area occupied by some European countries. In this vast territorial extension, much of which is barren and abandoned...we can find four or five million Mexicans sparsely spread, with no industry other than agriculture, lacking raw materials and the elements to work, having neither the means nor the place to migrate in search of honest fortune; either they turn lazy, turn to crime or, out of necessity, live under the monopolist [latifundista] that condemns them to live in misery under exorbitant conditions" (Tena 1964, p. 574; translation and brackets mine).

In the final part of his rather long address to Congress, Arriaga proposes, among other things, the following: "1. The right of ownership is based on occupation and possession...but it is confirmed and perfected by work and production. The accumulation in the hands of one or a few persons of great territorial extensions which are without work, crop, or production, is against common welfare..." (Tena 1964, p. 592; my translation).

The revolution gave way to the Political Constitution of 1917, in which the new agrarian ideology of the country was finally defined in Article 27: "Ownership of the lands and waters included within the boundaries of the national territory belongs originally to the Nation, which has held and still holds the right to transfer ownership of them to private persons, thereby constituting private property." Tucker (1957, p. 274) analyzes this section of the Constitution, which in general sought to accomplish three things: define and limit property, decide who may own and hold property, and solve the agrarian problem. By creating Article 27, the Constitution of 1917 tried to put an end to the accumulation of land and waters, and of the natural resources of the country in general.

From the revolutionary period and adoption of the Constitution of 1917 to date, different administrations gave agrarianism varying degrees of importance. Agriculture was still, for the most part, stagnant, at subsistence levels, and underdeveloped. The nation had gone through a devastating civil war. There were difficulties in implementing the new constitution, which required a great deal of management, and in general, it was difficult to enforce the agrarian dispositions mandated by the constitution. Independently of these problems, several pieces of legislature were enacted and served, to some extent, to initiate programs that led to later agricultural development.

A summary of important actions taken by administrations that served during this period is presented here, modified after Tucker (1957, pp. 276-280).

| President and Dates in Office | Actions |
| --- | --- |
| Alvaro Obregon (1920-1924) | Secured enaction of the Law of Ejidos (1920). |
| | Repealed the Law of Ejidos and passed the Agrarian Regulatory Law (1922). |
| | Created the National Agrarian Commission. |
| | Passed Idle Lands Law (1920). |
| | Passed a "Homestead-Type" decree (1923). |
| | Passed issuance of federal bonds to indemnify expropriated owners (1920). |
| Plutarco Elias Calles (1924-1928) | Passed Regulatory Law on Division of Ejido Land (1925). |
| | Passed Law of Dotation and Restitution of Lands and Waters (1927). |
| | Established the National Bank of Agricultural Credit (1926). |
| | Established ejido banks. |
| | Passed the Law of Irrigation with Federal Waters. |
| | Established the National Irrigation Commission (1926). |
| | Passed the Law of Colonization (1926). |
| Emilio Portes Gil (1929) | Passed National Waters Law (1929). |

| | |
|---|---|
| Pascual Ortiz Rubio (1930-1932) | Restricted the Law of Dotation and Restitution by passing "stop laws."<br>Passed the Law of December 23, 1931, which ended the availability of court review for expropriated owners.<br>Passed first law regulating Article 123: Provided for minimum wages, payment in legal tender, eight-hour work day, right to unionize, and protection for accidents and illness for agricultural labor. |
| Abelardo L. Rodriguez (1932-1934) | Passed Agrarian Code of 1934. |
| Lazaro Cardenas (1935-1940) | Promoted large cooperative farms.<br>Established the Agrarian Department.<br>Emphasized land redistribution. |

The period before 1940 was characterized by efforts to establish a base for future agricultural development. The Calles administration deserves special mention in the sense that real efforts were made to establish agricultural credit as well as agricultural education. After 1935, policies were aimed to improve production and to make an equitable distribution of factors of production (Hertford 1970, p. 90).

1940-1965 Period

During the 25-year period from 1940 to 1965 real progress was made in agriculture in Mexico. In fact, this was the best period in agriculture, or as Yates calls it, "the golden era of Mexican agriculture" (Yates 1981, p. 15). At the beginning of this period, the federal government invested heavily in large-scale irrigation projects, and encouraged opening new land to cultivation.

Manuel Avila Camacho, who took over the presidency after Cardenas, did not follow the same agrarian line as his predecessor. Because his administration (1940-1946) was during the period of World War II, industrial activity flourished. This, together with the Bracero Program, allowed large numbers of Mexicans to work temporarily in the United States and so helped ease the demand that the peasants were making for land.

When Miguel Aleman (1946-1952) took office, both ejidatarios and private property owners were asking for a legal framework that would guarantee their possession of the land. Some reforms were therefore made to Article 27 of the Constitution. During the Aleman administration, while the private agricultural sector grew, the ejido sector remained stagnant because most of the public investment on infrastructure was more beneficial to the private than to the ejido sector (Navarrete 1971, pp. 46-48). Regarding this, I. M. Navarrete (1971, p. 46) cites S. Eckstein, saying that "...by 1952 agricultural capital increased to reach the amount of 1,164 million pesos (pesos of 1950), while ejidal capital remained constant at 735 million pesos. Therefore, the ejidal contribution to total production decreased to 37.2%, having reached 50% in 1940" (my translation).

During Ruiz Cortines' administration (1952-1958), agricultural production reached standards higher than those in any previous administration. President Ruiz Cortines granted the guarantees that private-property owners were demanding. The ejido sector, on the other hand, was ignored by this administration and unrest came again to rural areas. The situation with respect to agricultural production had improved, but these prosperous farms were not able to absorb great numbers of laborers because of their trend towards mechanization and technification (Navarrete 1971). During the administration of Adolfo Lopez Mateos (1958-1964) the agrarian problem worsened. To alleviate this situation, the government distributed more land to peasants.

Post-1965 Period

The distribution of land as a measure to ease the unrest among the peasants continued into the administration of Gustavo Diaz Ordaz (1964-1970). Following the Diaz administration, President Luis Echeverria (1970-1976) attempted to find a solution to the agrarian problem facing the country. During his administration the Law of Agrarian Reform was enacted, and the Ministry of Agrarian Reform, formerly a Department of Agrarian Affairs and Colonization, was created. During the final year of the Echeverria administration the peso, which had kept a constant parity to the dollar for 22 years, devaluated as a consequence of the poor economic situation of the country and social unrest.

The administration of President Jose Lopez Portillo (since 1976) has implemented programs and incentives aimed at food production.

During his administration, importing foods has been seen as creating a dependence on other countries. The main programs implemented by Portillo, then, have been aimed at achieving autonomy in the production of food. These programs include the Mexican Alimentary System (SAM), the Law for Agricultural Promotion, and the National Program of Basic Products.

One thing that can be noticed, and that seems to be the common factor of each administration, is that agrarian reform concerned to a greater or lesser degree each of the presidents.

# CHAPTER 3

# GENERAL DESCRIPTION OF AGRICULTURE IN SONORA

To analyze Mexican agriculture at the regional level, the state of Sonora was chosen because it is one of the Mexican states representative of modern agricultural technology. The importance of Sonora in the agricultural context of the country has been emphasized by a number of authors, such as P. L. Yates in his Mexico's Agricultural Dilemma, C. H. de Alcantara in La Modernizacion de la Agricultura Mexicana 1940-1970, and C. M. Castanos in Testimonio de un Agronomo.

## Location, Topography, and Climate

Sonora, see Figure 3, is the second largest state in the Republic of Mexico; it is located in the northwest part of the country between 26°13' and 32°30' latitude north and between 108°27'18" and 115°03'28" longitude west. Sonora borders on the United States, mainly Arizona, for 588 kilometers. The western border along the Gulf of California measures 886 kilometers when measured in a straight line, and 1400 kilometers when measured along the seashore. To the northwest, Sonora borders on the state of Baja California Norte for 89 kilometers and to the east and south on Chihuahua and Sinaloa, respectively; the exact longitude of the borders among these three states is still disputed.

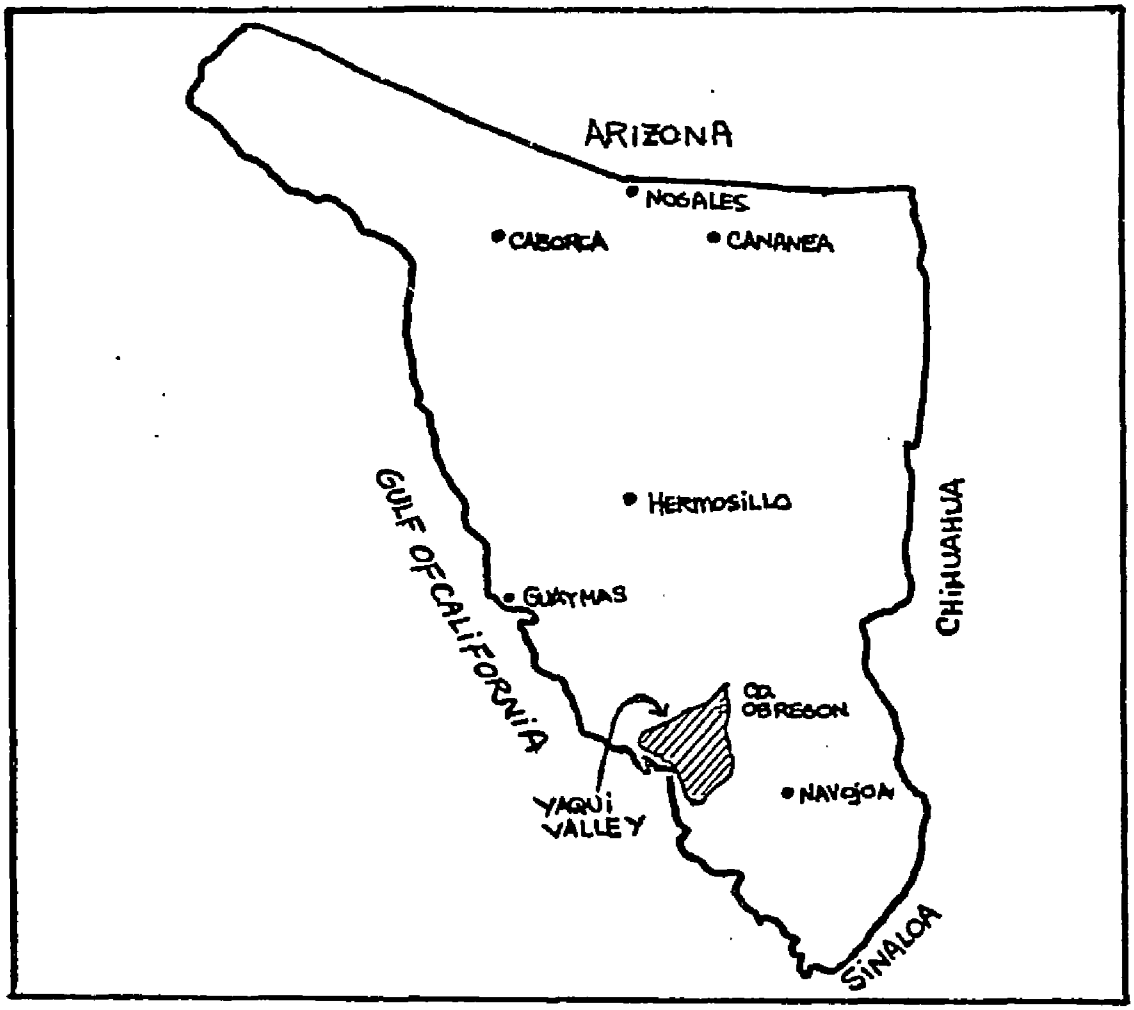


Figure 3. Map of Sonora.

The climate of Sonora varies considerably within the state. Roughly, three main climatic areas can be distinguished. Area I, which covers the coastal area of the state, can be classified as dry with temperatures ranging from semi-hot to very hot. Area II, which covers most of the central part of the state, from north to south, can be considered semi-dry with moderately hot to hot temperatures. And Area III, covering the southernmost eastern part of the state, is subhumid with temperatures ranging from semi-hot to moderately hot.

The area of Sonora is 18,493,400 hectares, representing 9.4% of the total area of Mexico. From the total area of the state, only 4%, or 713,329 hectares, is arable land. Of the remainder, 85% is considered grazing land, 1% forests, 9% desert, and 1% water bodies and settlements (SARH, Prontuario Estadistico Sonora Agropecuario).

Of interest for this study is the amount of arable land in the state. As stated above, arable land in the state covers an extension of 713,329 hectares. From these, 683,329 hectares, or 96% of the total amount of arable land, are irrigated. The rest, 30,000 hectares, or 4% of the total, is rainfed arable land.

Irrigation takes place in two forms: by gravity on 353,647 hectares, which is 52% of the total irrigated land, and by pumping groundwater on 329,682 hectares, or 48% of the total. Thus, the amount of land irrigated by pumping and that irrigated by gravity are almost equal in Sonora.

## Historical Review

Sonora was for centuries a desert used mainly for cattle raising and mining, with enough agriculture to meet local demands only (Alcantara 1978, p. 119). Nonetheless, the state had enough water resources to convert, if developed, the state into an important agricultural area.

The development of agriculture in Sonora started around 1890 when President Porfirio Diaz authorized a colonization program, financed mainly by banks in New York and Los Angeles, to divide the Yaqui Valley into land parcels and construct a network of channels for distribution of water (Alcantara 1978, p. 121).

This was the first step, the one that opened great extensions of land to agricultural use. However, rapid agricultural development in Sonora did not start until the forties. The reasons most often mentioned as causing this sudden agricultural development are heavy government investment in irrigation projects and the availability of adequate credit for farmers (Venezian and Gamble n.d., p. 14; Hertford 1970, p. 91; Hicks 1965, p. 93; Alcantara 1978, pp. 130-131; Yates 1981, pp. 72-73).

Between 1947 and 1958 the federal government invested 950 million pesos for irrigation projects in Sonora. This amount represented an investment of 8,250 pesos per person in the agricultural labor force in Sonora and was 25% of the federal budget for irrigation at that time (Alcantara 1978, p. 131). According to Hicks, "...investment in irrigation generally accounted for around 25% or more of the total investment in agriculture" (Hicks 1965, p. 93).

The availability of credit in Sonora was another of the factors that helped start agricultural development of the state. As Alcantara mentions, "fortunately, by the end of the decade of the forties, the state had one of the most advanced (private) banking systems in the nation...and the outstanding feature of the private banking operations in Sonora was...the predominance of agricultural credit..." (Alcantara 1978, pp. 132-133; my translation).

Between 1947 and 1952 a government bank, Banco Nacional de Credito Agricola, started distributing funds through private banking forms for the purposes of agricultural credit. The consequences of these governmental policies was "...an availability of credit for the agriculture of the private sector in Sonora which had no comparison to any other part of the nation" (Alcantara 1978, p. 134; my translation).

## CHAPTER 4

## ANALYSIS OF AGRICULTURAL PRODUCTION: NATIONAL LEVEL

This chapter analyzes in a quantitative way production trends and behavior during the seventies and part of the sixties. Most of the data to be analyzed were drawn from publications by the F.A.O. The purpose is to analyze what happened to Mexican agriculture after the "Golden Era" (1940-1965) and to compare the performance of Mexican and United States agriculture.

Relating agriculture to the economy as a whole, from Table 2 we see that the share of agriculture in the total gross domestic product (GDP), measured in pesos of 1960, was steadily declining throughout the seventies.

Table 2. Share of Agricultural Production in Gross Domestic Product, Mexico, 1970-1980

| Year | Share (%) | Rate of Change |
|---|---|---|
| 1970 | 7.13 | |
| 1971 | 7.01 | - 1.7 |
| 1972 | 6.37 | - 9.1 |
| 1973 | 6.04 | - 5.2 |
| 1974 | 5.98 | - 2.5 |
| 1975 | 5.62 | - 4.6 |
| 1976 | 5.48 | - 2.5 |
| 1977 | 5.66 | 3.3 |
| 1978 | 5.56 | - 1.8 |
| 1979 | 4.97 | -10.6 |
| 1980 | 4.95 | - 0.4 |
| Mean | 5.88 | - 3.5 |
| Std. Dev.[a] | 4.00 | 4.1 |

Source: Banamex, S.A., Mexico en Cifras, 1970-1980, 1981.

[a]Standard deviation calculated from residuals as shown in Appendix A.

The share of agriculture, in Mexico's GDP, has been decreasing at an annual average rate of -3.5%. The only time in this decade when the share actually increased was from 1976 to 1977.

## Total Production

Even though the share of agriculture in the gross domestic product of Mexico was decreasing, agricultural production, on the other hand, was increasing from 1967 to 1978. This can be seen in Table 3 for both Mexico and the United States.

Table 3. Index Numbers of Total Agricultural Production for Mexico (M1) and the United States (U1), 1967-1979 (1969-1971=100)

| | Mexico | | United States | |
|---|---|---|---|---|
| Year | M1 | % change | U1 | % change |
| 1967 | 94 | | 97 | |
| 1968 | 98 | 4.3 | 98 | 1.0 |
| 1969 | 96 | -2.0 | 98 | 0.0 |
| 1970 | 100 | 4.2 | 97 | -1.0 |
| 1971 | 105 | 5.0 | 104 | 7.2 |
| 1972 | 107 | 1.9 | 104 | 0.0 |
| 1973 | 110 | 2.8 | 106 | 1.9 |
| 1974 | 115 | 4.5 | 107 | 0.9 |
| 1975 | 113 | -1.7 | 113 | 5.6 |
| 1976 | 113 | 0.0 | 117 | 3.5 |
| 1977 | 123 | 8.8 | 122 | 4.3 |
| 1978 | 131 | 6.5 | 120 | -1.6 |
| 1979 | 133 | 1.5 | 126 | 5.0 |
| Mean | 110.6 | 3.0 | 108.4 | 2.2 |
| Std. dev.[a] | 2.8 | 3.2 | 2.2 | 2.8 |

Source: F.A.O. Production Yearbook, Vol. 33, 1979.

[a]Standard deviation for index numbers was calculated from residuals as shown in Appendix A.

Agricultural production in Mexico (M1) increased in the 13-year period from 1967 to 1979 at an annual average rate of 3% with only two major recessionary periods, 1968-1969 and 1974-1975. This rate of increase, however, was lower than the growth of total production (GDP). From 1970 to 1980, total production grew at an annual average rate of 5.8% as compared to only 3% of agriculture.

The trend of index numbers (M1) with respect to time (see Figure 4 and Appendix A) shows a positive slope of 3.13, an average annual index of 110.6, and a standard deviation of 2.8. For the United States, agricultural production (U1) has been increasing at an annual average rate of 2.2%. Figures regarding the performance for both countries are summarized in Table 4.

Table 4. Summary of Agricultural Production Statistics for Mexico and the United States, 1967-1979

| | Mexico | United States |
|---|---|---|
| Mean index (1969-71=100) | 110.6 | 108.4 |
| Standard deviation | 2.8 | 2.2 |
| Slope of trend | 3.13 | 2.53 |
| Corr. coefficient | 0.968 | 0.968 |

Source: Appendix A.

Although statistical analyses show no significant differences, perhaps agricultural production in the United States can be considered as increasing in a more homogeneous, smoother fashion than that of Mexico. Agricultural production in Mexico shows greater increases per year than that of the United States, and this difference is evident from the larger slope on the time trend for Mexico.

Figure 4 shows that Mexican agricultural production growth surpassed United States growth around 1969; however, this statement is inconclusive because of the short period being considered. Although agricultural production in Mexico has grown during the seventies, the growth has not kept pace with population growth, which for the period 1960-1979 maintained an annual average rate of growth of 3.4%. Indeed, there seems to be an inverse relationship between growth of agricultural production and of population. This relationship is perhaps better explained by Table 5 and Figure 5, where striking differences in per capita agricultural production are shown for Mexico and the United States.

Table 5. Index Numbers of Per Capita Agricultural Production for Mexico (M2) and the United States (U2), 1967-1979 (1969-1971=100)

| | Mexico | | United States | |
|---|---|---|---|---|
| Year | M2 | % change | U2 | % change |
| 1967 | 104 | | 100 | |
| 1968 | 104 | 0.0 | 100 | 0.0 |
| 1969 | 99 | -4.8 | 99 | -1.0 |
| 1970 | 100 | 1.0 | 97 | -2.0 |
| 1971 | 102 | 2.0 | 103 | 6.2 |
| 1972 | 101 | -1.0 | 102 | -1.0 |
| 1973 | 100 | -1.0 | 103 | 1.0 |
| 1974 | 101 | 1.0 | 104 | 4.8 |
| 1975 | 96 | -5.0 | 109 | 1.8 |
| 1976 | 93 | -3.1 | 111 | 3.6 |
| 1977 | 98 | 5.4 | 115 | -2.6 |
| 1978 | 101 | 3.1 | 112 | 4.5 |
| 1979 | 99 | -2.0 | 117 | |
| Mean | 99.8 | -0.4 | 105.5 | 1.4 |
| Std. dev. | 2.5 | 3.1 | 2.4 | 2.9 |

Source: F.A.O. Production Yearbook, Vol. 33, 1979.

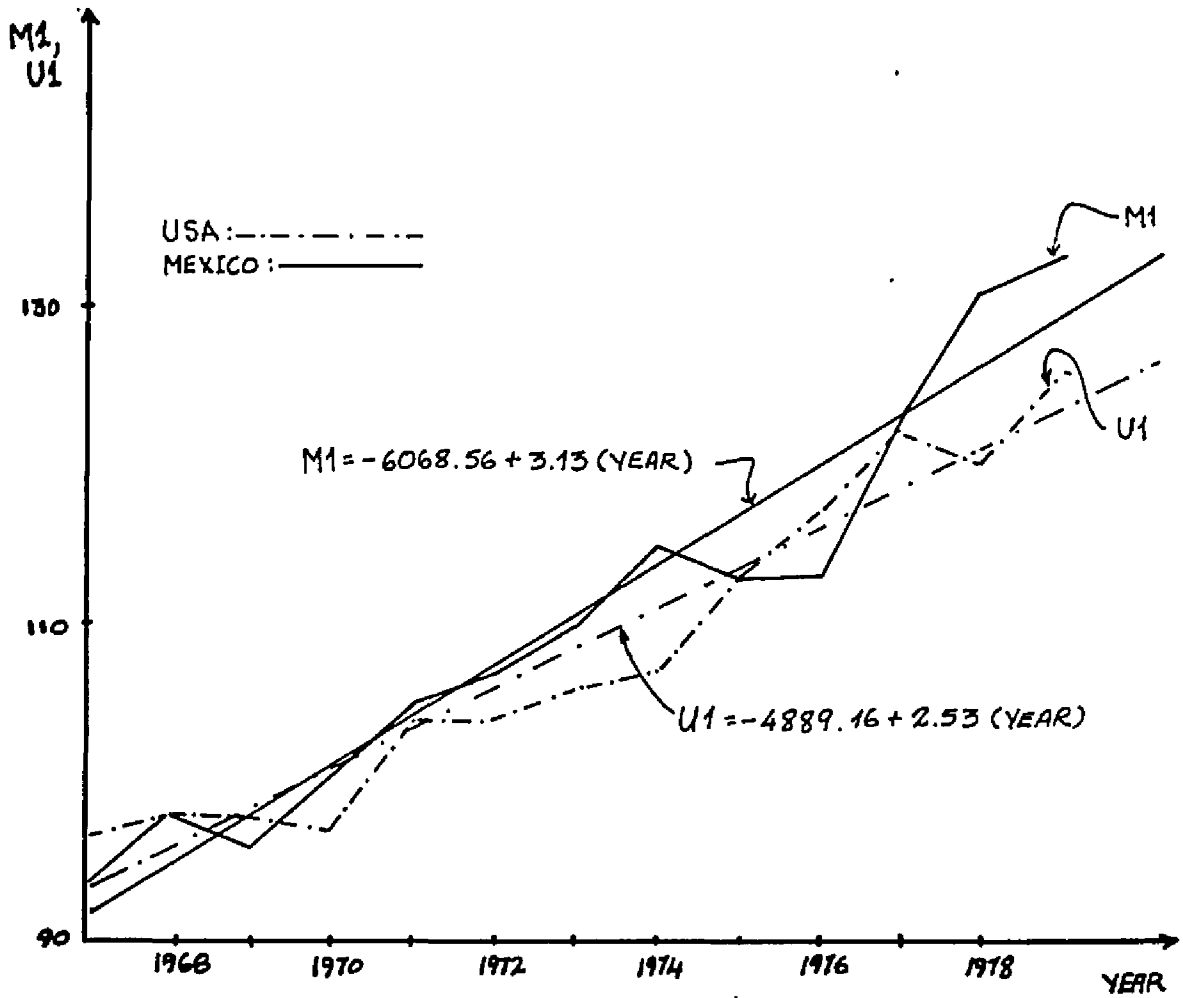


Figure 4. Index numbers of agricultural production for Mexico (M1) and and the United States (U1), 1967-1979.

Source: Table 3.

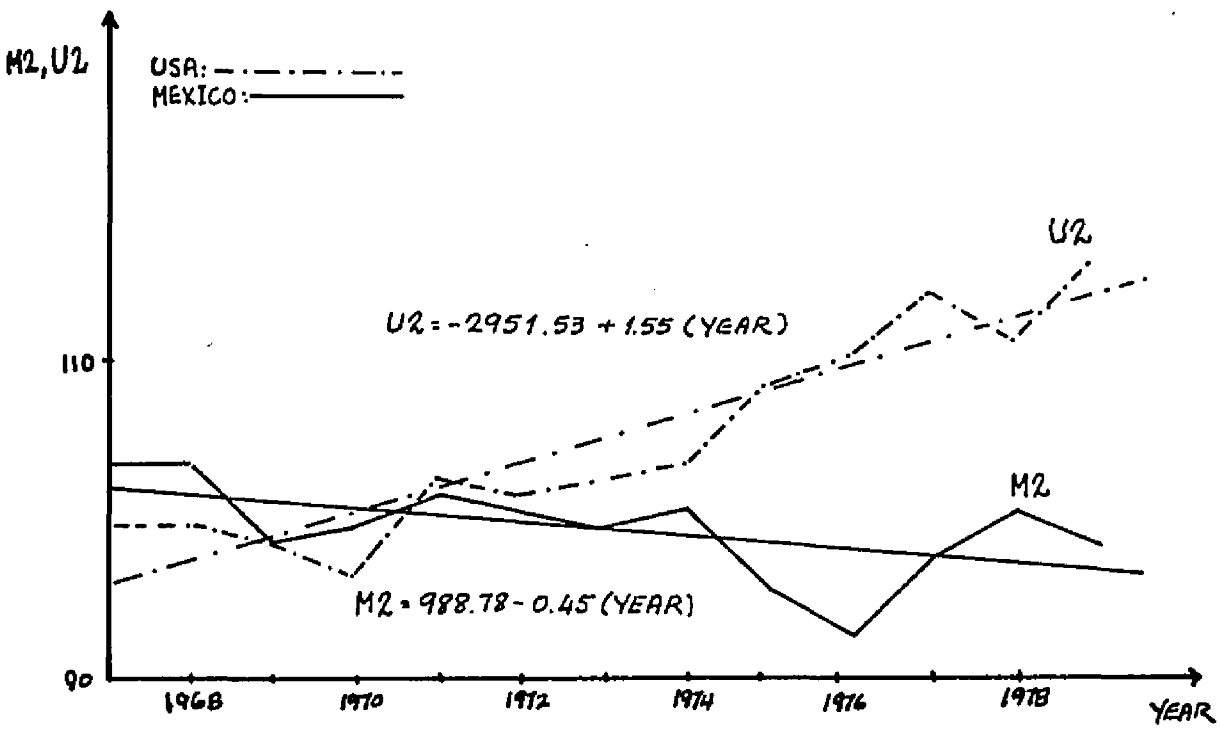


Figure 5. Index numbers of per capita agricultural production for Mexico (M2) and the United States (U2), 1967-1979.

Source: Table 5.

The average annual growth rate of per capita agricultural production for Mexico was negative for the period 1967-1979. When compared with the average annual growth rate for the United States, we see a tremendous difference: -0.37% for Mexico and 1.4% for the United States. Figure 5 depicts this difference. The linear trend of Mexico has a negative slope of -0.45 and the United States has a positive slope of 1.55.

Agricultural production in Mexico, although it has been increasing, has not kept pace with a growing demand for agricultural products and has been decreasing relative to total domestic production.

## Selected Agricultural Production Inputs

The analysis of Mexican agricultural production in this study centers around the utilization of selected inputs used in production. It will be a difficult task to enumerate and analyze all inputs that may affect agricultural production; therefore, only those inputs for which data are readily available will be included here. These selected inputs are land, agricultural labor, fertilizer, and machinery.

The productivity of each of these four inputs will be analyzed by simply dividing the index of total production by the index of amount of input used and multiplying by 100, for a given year.

### Land Input

General Considerations. A much debated input in Mexican agriculture has been land. Throughout the years, land has undergone physical and social transformations that were aimed at improving either productivity or social conditions in the country. Development economists have often wondered whether to increase productivity first and then make an equal distribution of wealth, or to do both at the same time. In Mexico, and probably in most of the developing countries, land is associated with wealth; therefore, a redistribution of land is equivalent to a redistribution of wealth. At least that is what is intended by government officials.

Redistribution of land in Mexico is slow and seems to have no end; it has been going on since 1917. This situation has been a major problem for private farmers who have to deal with another type of uncertainty and, on the average, avoid heavy investment to improve their land. Redistribution of land has taken place in Mexico through the formation of ejidos. For a detailed explanation of what an ejido is, and how it operates, see Yates's Mexico's Agricultural Dilemma, pp. 140-150. The redistribution of land, although a law since 1917, was not enforced strictly until after 1930. Redistribution decreased during the forties and fifties and increased again during the sixties and seventies (Yates, 1981).

The amount of land used for crops has been increasing slowly in Mexico. It has increased at an annual average rate of 0.8%. In the United States it has been increasing at an annual average rate of 1.4%; these figures come from Table 6.

Table 6. Arable Land and Index Numbers for Mexico (M3) and the United States (U3), 1964-1969 (1969-1971=100)

| | Mexico | | | United States | | |
|---|---|---|---|---|---|---|
| Year | Land (x $10^3$ ha) | M3 | % Change | Land (x $10^3$ ha) | U3 | % Change |
| 1964 | 23810 | 93.4 | | 177966 | 93.0 | |
| 1965 | 24140 | 94.7 | 1.4 | 177000 | 92.4 | -0.5 |
| 1966 | 24470 | 96.0 | 1.4 | 175705 | 91.7 | -0.7 |
| 1967 | 24790 | 97.2 | 1.3 | 174487 | 91.1 | -0.7 |
| 1968 | 25110 | 98.5 | 1.3 | 181000 | 94.5 | 3.7 |
| 1969 | 25440 | 99.8 | 1.3 | 189283 | 98.8 | 4.6 |
| 1970 | 25776 | 101.2 | 1.4 | 190185 | 99.3 | 0.5 |
| 1971 | 25290 | 99.2 | -2.0 | 195250 | 101.9 | 2.7 |
| 1972 | 25320 | 99.3 | 0.1 | 192250 | 100.4 | -1.5 |
| 1973 | 25595 | 100.3 | 1.0 | 201060 | 105.0 | 4.6 |
| 1974 | 25620 | 100.5 | 0.2 | 205080 | 107.0 | 2.0 |
| 1975 | 26220 | 102.8 | 2.3 | 207376 | 108.2 | 1.1 |
| 1976 | 26000 | 102.0 | -0.8 | (209027) | 109.1 | 0.8 |
| 1977 | (26384) | 103.5 | 1.5 | (212126) | 110.7 | 1.5 |
| 1978 | (26553) | 104.1 | 0.6 | (215224) | 123.3 | 1.4 |
| 1979 | (26722) | 104.8 | 0.7 | (218322) | 114.0 | 1.4 |
| Mean | 25452 | 99.8 | 0.8 | 195084 | 102.5 | 1.4 |
| Std. Dev. | 845 | 1.0 | 1.0 | 15058 | 2.8 | 1.8 |

Source: F.A.O. Production Yearbook, various issues.
Note: Values in parentheses are linearly trended.

In the case of the United States, referring to Table 6, the series starts with a decreasing trend, but then increases and keeps this trend throughout the series. In the case of Mexico, the series shows a slow increasing trend throughout, except for two years, 1970-1971 and 1975-1976.

Productivity Measures. The productivity of land was measured using the method previously described.

Table 7 shows the results obtained. From these results and from Figure 6, we can see that the productivity of land increased in both countries. For Mexico it increased from 1967 to 1979 at an average annual rate of 2.4%, whereas for the United States it increased somewhat more slowly, at a rate of 0.5%.

Table 7. Land Productivity Indices for Mexico (LPM) and the United States (LPU), 1967-1979

| Year | Mexico LPM[a] | Mexico % change | United States LPU[b] | United States % change |
|---|---|---|---|---|
| 1967 | 96.7 | | 106.5 | |
| 1968 | 99.5 | 2.9 | 103.7 | -2.6 |
| 1969 | 96.2 | -3.3 | 99.2 | -4.3 |
| 1970 | 99.8 | 2.7 | 97.7 | -1.5 |
| 1971 | 105.8 | 7.1 | 102.1 | 4.5 |
| 1972 | 107.8 | 1.9 | 108.6 | 1.5 |
| 1973 | 109.7 | 1.8 | 101.0 | -2.5 |
| 1974 | 114.4 | 4.3 | 100.0 | -1.0 |
| 1975 | 109.9 | -4.0 | 104.4 | 4.4 |
| 1976 | 110.8 | 0.8 | 107.2 | 2.7 |
| 1977 | 118.8 | 7.2 | 110.2 | 2.8 |
| 1978 | 125.8 | 5.9 | 97.3 | -11.7 |
| 1979 | 126.9 | 0.9 | 110.5 | 13.6 |
| Mean | 109.3 | 2.4 | 103.3 | 0.5 |
| Std. dev. | 2.8 | 3.6 | 4.0 | 6.1 |

Source: Tables 3 and 6.

[a] LPM = ((M1/M3) x 100)

[b] LPU = ((U1/U3) x 100)

The trend for Mexico has a slope of 2.5 and a correlation coefficient of 0.95. For the United States, we see a major decrease in productivity from 1967 to 1970, and again from 1972 to 1974. The values yield a slope of 0.33 and a correlation coefficient of 0.3 (tests of significance for each regression are included in Appendix A).

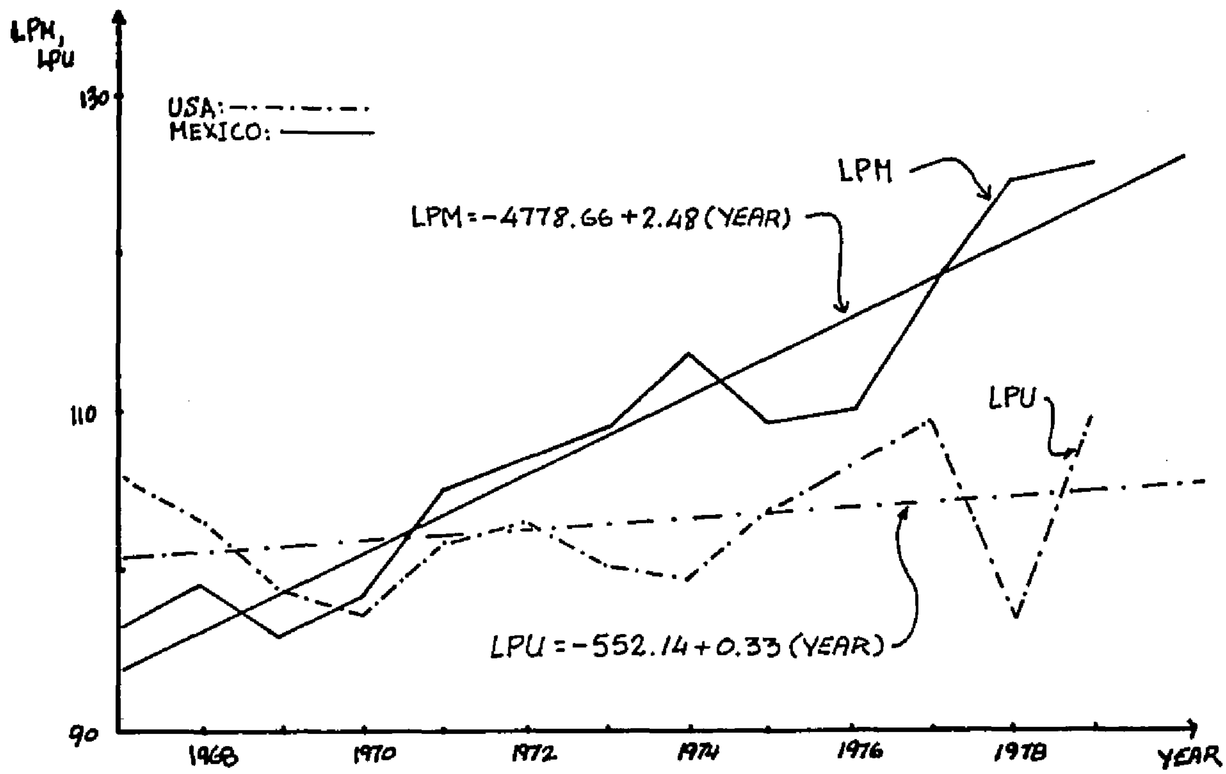


Figure 6. Land Productivity for Mexico (LPM) and the United States (LPU), 1967-1979.

Source: Table 7.

It is interesting to see, from Table 7, that the productivity of land in Mexico steadily increased throughout the period 1967-1979, while that of the United States did not.

## Agricultural Labor

General Considerations. Although a high percentage of the economically active population (EAP) in Mexico is still engaged in agriculture, this percentage has been decreasing over the past 20 years. Table 8 shows the percent of economically active population in Mexican agriculture.

Table 8. Percent of Economically Active Population in Agriculture, Mexico, 1960-1979

| Year | % | % change |
|---|---|---|
| 1960 | 55.1 | |
| 1965 | 50.3 | - 8.7 = 1.7 annual |
| 1970 | 45.2 | -10.1 = 2.0 annual<br>= 18% from 1960-1970 |
| 1975 | 40.5 | -10.4 = 2.1 annual |
| 1976 | 39.6 | - 2.2 |
| 1977 | 38.7 | - 2.3 |
| 1978 | 37.8 | - 2.3 |
| 1979 | 36.9 | - 2.4 |

Source: F.A.O. Production Yearbook, various issues.

Table 8 indicates that there were significant decreases in the percentage of EAP in agriculture from 1960 to 1970 of about 18%. In the next decade, measured from 1970 to 1979, the decrease was 18.4%. The agricultural labor force, on the other hand, has been increasing at an average annual rate of 1%, as shown in Table 9.

Table 9. Agricultural Labor Force and Index Numbers for Mexico (M4) and the United States (U4), 1965-1979 (1969-1971=100)

| Year | Ag. Labor | Mexico M4 | % change | Ag. Labor | United States U4 | % change |
|---|---|---|---|---|---|---|
| 1965 | 6 292 | 96.0 | | 4 050 | 129.7 | |
| 1966 | (6 335) | 96.6 | 0.7 | (3 688) | 115.4 | -8.9 |
| 1967 | (6 339) | 96.7 | 0.1 | (3 559) | 111.3 | -3.5 |
| 1968 | (6 445) | 98.3 | 1.7 | (3 531) | 110.5 | -0.8 |
| 1969 | (6 495) | 99.0 | 0.8 | (3 332) | 104.2 | -5.6 |
| 1970 | 6 555 | 100.0 | 0.9 | 3 197 | 100.0 | -4.0 |
| 1971 | (6 621) | 100.9 | 0.9 | (3 061) | 95.8 | -4.2 |
| 1972 | (6 694) | 102.1 | 1.2 | (3 003) | 93.9 | -1.9 |
| 1973 | (6 767) | 103.2 | 1.1 | (2 854) | 89.3 | -5.0 |
| 1974 | (6 840) | 104.3 | 1.1 | (2 752) | 86.1 | -3.6 |
| 1975 | 6 910 | 105.4 | 1.1 | 2 598 | 81.3 | -5.6 |
| 1976 | 6 992 | 106.6 | 1.1 | 2 523 | 78.9 | -2.9 |
| 1977 | 7 060 | 106.7 | 1.0 | 2 413 | 75.5 | -4.4 |
| 1978 | 7 132 | 108.8 | 1.0 | 2 329 | 72.9 | -3.5 |
| 1979 | 7 206 | 109.9 | 1.0 | 2 249 | 70.4 | -3.4 |
| Mean | 6 712 | 102.3 | 1.0 | 3 009 | 94.3 | -4.1 |
| Std. dev. | 303 | 0.4 | 0.3 | 544 | 2.6 | 1.9 |

Source: F.A.O., Production Yearbook, various issues.
Note: Values in parentheses are linearly trended, for Mexico. Values in parentheses for the United States were calculated as explained in Appendix A.

Comparing the agricultural labor force of Mexico with that of the United States, the contrast between these two countries is evident. The agricultural labor force of the United States (see Table 9), has been decreasing at an average annual rate of -4.1% for the period 1965-1979, whereas in Mexico, as mentioned before, it has been increasing at approximately 1% per year for the same period of time.

It is interesting to compare agricultural labor force, total labor force, and total agricultural population in Mexico for the period 1960-1979. Total agricultural population increased at an annual average rate of 3.4%, total labor force increased at an annual average rate of 3.3%, but agricultural labor force increased only at an annual average rate of 1%. This implies that part of the agricultural population is being assimilated by other sectors of the economy.

Rodriguez Cisneros, et al. (no year given), analyzed the inter-sectoral transference of labor for the period 1950 to approximately 1970. They found that while the EAP in agriculture rose at an average annual rate of 1.2%, that of industry grew at 5.1% and services at 4.3%. The percentage of agriculture's EAP dropped from 58.5% in 1950 to 43% in 1969, while industry increased from 15.9% to 23.9% and services from 25.6% to 33.2% for the same years (Rodriguez Cisneros, et al., p. 121). They comment that "when non-agricultural activities began to expand in a sustained form, an important transfer of labor started to take place from the agricultural sector to these (non-agricultural) activities" (p. 119; my translation). This transference could have also taken place during the seventies.

Productivity Measures. The results of the analysis are shown in Table 10 for both Mexico and the United States. Productivity of the agricultural labor force in Mexico has been increasing at an average annual rate of 1.9%. Total labor productivity in Mexico has also had major increases. These occurred during the years 1970-1971, 1973-1974, and 1976-1979. At other times total productivity decreased, particularly from 1968 to 1969 and from 1974 to 1976.

For the United States, agricultural labor productivity has been increasing over the entire period. The average annual rate of increase in productivity for 1967-1979 was 6.2%; major increases occurred during the years 1970-1971, 1974-1975, and 1976-1977. Productivity of agricultural labor for Mexico differed significantly from that of the United States. This difference can be seen in Figure 7, where the trends in both productivities over time are depicted. The slope of the productivity trend for Mexico is 1.92, whereas the slope for the United States is 7.85, although growth in productivity for Mexico has been somewhat smoother than that of the United States, as suggested by the differences in the standard deviations for both countries.

Table 10. Productivity of Total Agricultural Labor Force, Indices for Mexico (LBPM) and the United States (LBPU), 1967-1979

| Year | Mexico | | United States | |
|---|---|---|---|---|
| | LBPM[a] | % change | LBPU[b] | % change |
| 1967 | 97.2 | | 87.2 | |
| 1968 | 99.7 | 2.5 | 88.6 | 1.6 |
| 1969 | 97.0 | -2.7 | 94.0 | 6.1 |
| 1970 | 100.0 | 3.1 | 97.0 | 3.2 |
| 1971 | 104.0 | 4.0 | 108.6 | 12.0 |
| 1972 | 105.0 | 1.0 | 110.8 | 2.0 |
| 1973 | 106.6 | 1.5 | 118.7 | 7.1 |
| 1974 | 110.3 | 3.5 | 124.3 | 4.7 |
| 1975 | 107.2 | -2.8 | 139.0 | 11.8 |
| 1976 | 106.0 | -1.1 | 148.3 | 6.7 |
| 1977 | 115.3 | 8.8 | 161.6 | 9.0 |
| 1978 | 120.4 | 4.4 | 164.6 | 1.8 |
| 1979 | 121.0 | 0.5 | 179.0 | 8.7 |
| Mean | 106.9 | 1.9 | 124.7 | 6.2 |
| Std. dev. | 2.6 | 3.6 | 5.0 | 3.7 |

[a]LBPM = ((M1/M4) x 100)

[b]LBPU = ((U1/U4) x 100)

Source: Tables 3 and 9.

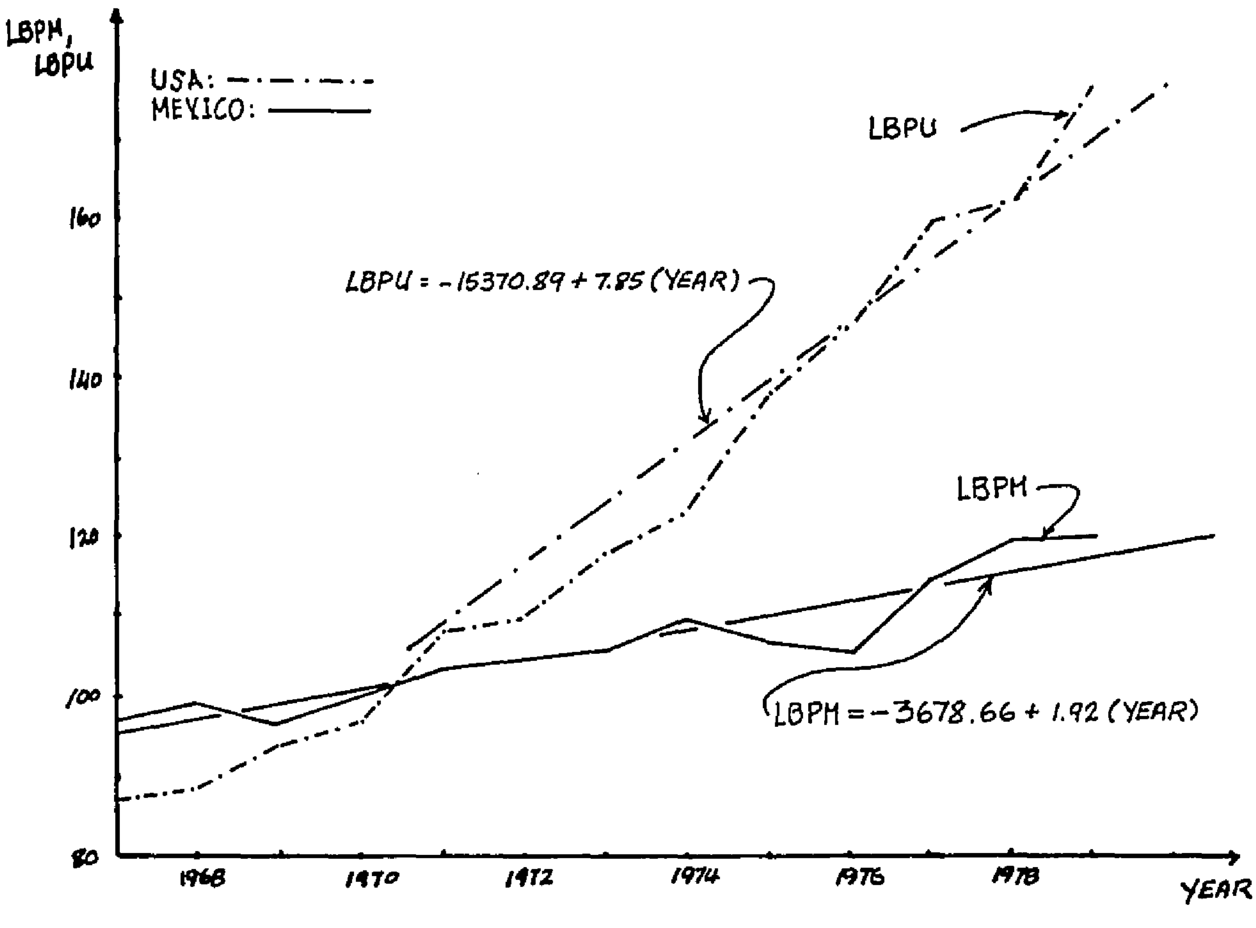


Figure 7. Labor productivity for Mexico (LBPM) and the United States (LBPU), 1967-1979.

Source: Table 10.

Fertilizer Input

General Considerations. The use of fertilizer has long been regarded as a method of improving agricultural production. In other words, it has been regarded as a modernization of agriculture. In Mexico, increased use of fertilizer started after 1950. Before this time, as mentioned in the report of the Combined Mexican Working Party (1953, p. 30), "the use of fertilizer is at a low level and did not increase significantly in the 12-year period 1939-1950." The same report says (p. 30) that fertilizer has been used only for a few crops in newly developed agricultural lands. Venezian and Gamble (1966, p. 14) also comment on this situation, saying that fertilizer use grew rapidly since 1950, and accounted for the significant increases in agricultural production in Mexico.

The concern of the Mexican government with fertilizer as a major input for increasing agricultural production began in 1952 when the government corporation GUANOMEX, now FERTIMEX, was created. FERTIMEX is engaged in the production and distribution of fertilizers. Hertford (1970, p. 94) reports that "since 1952, when GUANOMEX was established, Mexican fertilizer consumption has increased about tenfold (from 31,000 to almost 300,000 metric tons of primary nutrients), the greatest share of this increase going to government irrigation districts."

Most of the increased use of fertilizer has been in irrigated areas because the erratic rainfall in rainfed areas prevents taking full advantage of this input. From 1951 to 1960, says Rodriguez Cisneros (p. 79), "...the greatest increases in area fertilized were observed in the Northwest (27.5% annual average), Northeast (18.47% annual average), Bajio (13%) and South (11.0%)....By 1967 the highest levels in the coefficient of fertilized area were held by the Northwest, which was fertilizing 60.2% of its area harvested..." (my translation).

To measure the consumption of fertilizer, physical quantities of nitrogen (N), phosphorus ($P_2O_5$), and potassium ($K_2O$) consumed were simply added (see Hayami and Ruttan, 1971, p. 333). Using this measure, Table 11 shows that fertilizer consumption has been increasing in Mexico at an average annual rate of 9.3% compared with 5.5% for the United States. The data presented show an increasing trend for both countries, although the trend for Mexico increases more rapidly. The slope of the Mexican trend is 10.2 compared with the 4.4 slope of the trend for the United States. Probably this difference arises from the different starting bases; that is, when Mexico starts from 321,000 metric tons in 1964, the United States starts from 9,953,900 metric tons for the same year.

Table 12 shows the amount of fertilizer per hectare of arable land. The average amount applied per hectare is 27.3 kilograms for Mexico and 80.2 kilos for the United States, almost four times the amount applied in Mexico.

The number of kilos of fertilizer per hectare has been increasing at an annual average rate of 8.4% for Mexico, double the United States rate. However, the amount of fertilizer applied per hectare in the United States was at least double the amount applied in Mexico in any year.

Table 11. Fertilizer Consumption and Index Numbers for Mexico (M5) and the United States (U5), 1964-1978 (1969-1971=100)

| Year | Mexico Fertilizer (x $10^3$ mt. tns.) | Mexico M5 | Mexico % change | United States Fertilizer (x $10^3$ mt. tns.) | United States U5 | United States % change |
|---|---|---|---|---|---|---|
| 1964 | 321.3 | 52.6 | | 9.9 | 65.4 | |
| 1965 | 343.3 | 56.2 | 6.8 | 11.3 | 74.1 | 13.3 |
| 1966 | 390.0 | 63.8 | 13.6 | 12.7 | 83.3 | 12.4 |
| 1967 | 429.1 | 70.3 | 10.0 | 13.6 | 89.6 | 7.6 |
| 1968 | 498.6 | 81.6 | 16.2 | 13.9 | 91.1 | 1.7 |
| 1969 | 546.0 | 89.4 | 9.5 | 14.5 | 95.1 | 4.4 |
| 1970 | 593.3 | 97.1 | 8.7 | 15.6 | 102.3 | 7.6 |
| 1971 | 693.0 | 113.5 | 16.8 | 15.6 | 102.6 | 0.3 |
| 1972 | 669.8 | 109.7 | -3.3 | 16.3 | 107.3 | 4.5 |
| 1973 | 731.7 | 119.8 | 9.2 | 17.5 | 115.2 | 7.4 |
| 1974 | 922.2 | 151.0 | 26.0 | 15.9 | 104.3 | -9.5 |
| 1975 | 1 073.5 | 175.8 | 16.4 | 19.9 | 124.2 | 19.1 |
| 1976 | 1 120.3 | 183.4 | 4.4 | 20.0 | 131.6 | 5.9 |
| 1977 | 1 067.7 | 174.8 | -4.7 | 18.7 | 122.6 | -6.8 |
| 1978 | 1 066.6 | 174.8 | 0.0 | 20.3 | 133.5 | 8.9 |
| Mean | 697.8 | 114.2 | 9.3 | 15.7 | 102.8 | 5.5 |
| Std. dev. | 287.0 | 9.6 | 8.4 | 3.2 | 4.9 | 7.5 |

Source: Compiled from Alcantara, La Modernizacion de la Agricultura en Mexico 1940-1970, Siglo Veintiuno Eds. Mexico, 1978 (1964-1969 for Mexico), and F.A.O., Production Yearbook, various issues.

Note: Values in the table are rounded values of the original figures used to calculate the indices M5 and U5.

Table 12. Fertilizer per Hectare and Index Numbers for Mexico and the United States, 1964-1978 (1969-1971=100)

| Year | Mexico (kg/ha) | Index | % change | United States (kg/ha) | Index | % change |
|---|---|---|---|---|---|---|
| 1964 | 13.5 | 56.2 | | 55.9 | 70.5 | |
| 1965 | 14.2 | 59.2 | 5.2 | 63.7 | 80.3 | 14.0 |
| 1966 | 15.9 | 66.2 | 12.0 | 72.1 | 90.9 | 13.2 |
| 1967 | 17.3 | 72.1 | 8.1 | 78.2 | 98.6 | 8.5 |
| 1968 | 19.9 | 82.9 | 15.0 | 76.7 | 96.7 | -1.9 |
| 1969 | 21.5 | 89.6 | 8.0 | 76.5 | 96.5 | -0.3 |
| 1970 | 23.0 | 95.8 | 7.0 | 81.5 | 102.8 | 6.5 |
| 1971 | 27.4 | 114.2 | 19.1 | 80.0 | 101.0 | -1.8 |
| 1972 | 26.5 | 110.4 | -3.3 | 85.0 | 107.2 | 6.2 |
| 1973 | 28.6 | 119.2 | 7.9 | 87.3 | 110.1 | 2.7 |
| 1974 | 36.0 | 150.0 | 25.9 | 77.4 | 97.6 | -11.4 |
| 1975 | 41.0 | 170.8 | 14.0 | 91.2 | 115.0 | 17.8 |
| 1976 | 43.1 | 179.6 | 5.1 | 95.8 | 120.8 | 5.0 |
| 1977 | 40.5 | 169.8 | -6.0 | 88.0 | 111.0 | -8.1 |
| 1978 | 40.2 | 167.5 | -0.7 | 94.4 | 119.0 | 7.3 |
| Mean | 27.3 | 113.6 | 8.4 | 80.2 | 101.2 | 4.1 |
| Std. dev. | 10.5 | 9.0 | 6.5 | 10.9 | 6.4 | 6.5 |

Source: Tables 6 and 11.

Productivity Measures. Table 13 shows the productivity of fertilizer for both countries. The data show that the productivity of fertilizer decreased in both countries. In Mexico it decreased at an average annual rate of 4.7%, whereas in the United States the decrease averaged 1.3% per year. See Figure 8, where these data are depicted.

Table 13. Productivity of Fertilizer, Indices for Mexico (FPM) and the United States (FPU), 1967-1978

| | Mexico | | United States | |
|---|---|---|---|---|
| Year | FPM[a] | % change | FPU[b] | % change |
| 1967 | 133.7 | | 108.3 | |
| 1968 | 120.1 | -10.2 | 107.6 | -0.7 |
| 1969 | 107.4 | -10.6 | 103.0 | -4.2 |
| 1970 | 103.0 | -4.1 | 94.8 | -8.0 |
| 1971 | 92.5 | -10.2 | 101.4 | 7.0 |
| 1972 | 97.5 | 5.4 | 96.9 | -4.4 |
| 1973 | 91.8 | -5.8 | 92.0 | -4.8 |
| 1974 | 72.6 | -17.0 | 102.6 | 11.5 |
| 1975 | 64.3 | -15.6 | 91.0 | -11.3 |
| 1976 | 61.6 | -4.2 | 88.9 | -2.3 |
| 1977 | 70.4 | 14.3 | 99.5 | 11.9 |
| 1978 | 74.9 | 6.4 | 90.0 | -9.5 |
| Mean | 91.1 | -4.7 | 98.0 | -1.3 |
| Std. dev. | 11.5 | 9.8 | 4.8 | 8.1 |

Source: Tables 11 and 3.

[a]FPM = ((M1/M5) x 100)

[b]FPU = ((U1/U5) x 100)

Machinery Input

General Considerations. Like the previous three inputs analyzed, investment in farm machinery and equipment was not significant until after 1950. Again, during the period from 1950 to 1965, the greatest share of investment was concentrated in the non-ejido sector of Mexican agriculture and in irrigated areas (Venezian and Gamble n.d.; USDA 1970; Hicks 1965). In recent years, however, the federal government has implemented a mechanization program that provides credit to the ejido sector for acquiring tractors and implements. Venezian and Gamble (p. 19) comment on the ejido situation, saying that "[the ejidos]...had

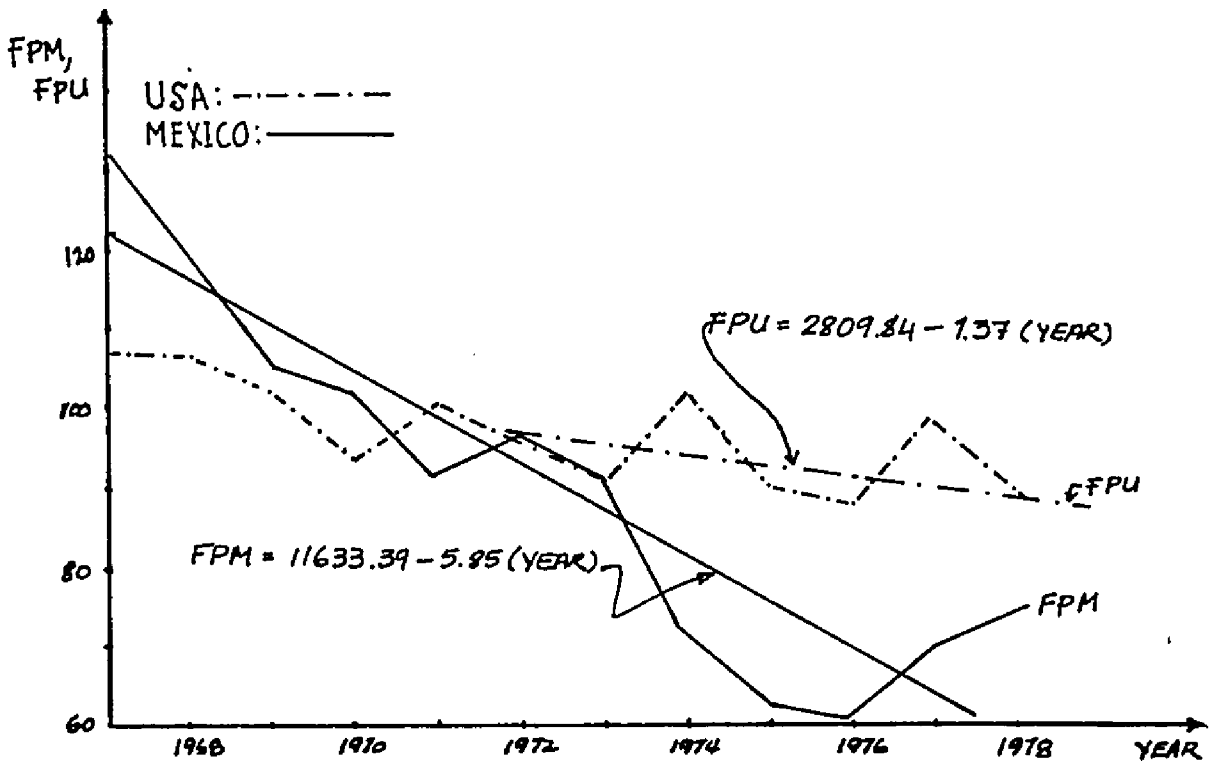


Figure 8. Fertilizer productivity for Mexico (FPM) and the United States (FPU), 1967-1978.

Source: Table 13.

only 16% of all tractors in 1950; by 1960, they had 20% of the total" (brackets mine).

Data published by the SARH in 1979 depict the current situation. From the total arable land in irrigation districts, 55.4% was totally mechanized, 33.4% was partially mechanized, and 11.2% was nonmechanized. Ejidos had approximately 54% of the total land (1,747,681 hectares), of which 53% was totally mechanized, 36% partially mechanized, and the rest nonmechanized. Private property owners had 46% of the total land, of which 58% was mechanized, 30% partially mechanized, and the rest nonmechanized. Ejidos and private property have about equal shares of mechanization.

Since it is not within the scope of this study to analyze differences between ejidos and private property, these data will not be further analyzed. They were presented only to show the development in investment patterns that has occurred since 1950.

It is interesting to see how mechanization occurs geographically. Table 14 presents data in this respect.

We must keep in mind that the data presented in Table 14 are only for lands in irrigation districts and are not representative of the national situation; nevertheless, the data illustrate our point. From the table we can see that the greatest percentage of area mechanized is in the northern part of the country (the sum of Northwest, North, Northeast, and North-Center regions), with 76.7% of the total. The northern part of the country also accounts for 72.7% of the total number of tractors; the rest is shared by the south. Again, it is necessary to stress that irrigation districts are not representative of the nation. These districts, on the average, use modern technology and extension services which increase their productivity.

Table 14. Use of Farm Machinery in Mexico, by Region, 1977-1978

| | NW | N | NE | NC | WE | C | GS | P |
|---|---|---|---|---|---|---|---|---|
| SM | 52.4 | 8.1 | 15.4 | 0.7 | 16.3 | 4.5 | 2.4 | 0.2 |
| NT | 46.9 | 13.0 | 11.4 | 1.4 | 20.4 | 5.2 | 1.5 | 0.1 |
| EMM | 59.0 | 32.9 | 71.5 | 27.4 | 42.2 | 45.7 | 82.8 | 55.6 |
| SNM | 3.0 | 5.4 | 36.7 | 0.1 | 34.7 | 15.3 | 14.0 | 1.8 |
| NTE | 19.8 | 13.2 | 8.6 | 1.8 | 27.4 | 24.1 | 3.7 | 1.5 |
| X | 19.3 | 4.5 | 16.6 | 3.0 | 5.4 | 1.9 | 7.9 | 1.7 |

Source: SARH, DGEA, La Mecanización Agrícola en los Distritos de Riego, Año Agrícola 1977-1978, Informe Estadístico No. 100, Mexico, D.F., Diciembre 1979.

Note: SM = percent area where farm machinery is used; NT = percent number of tractors; EMM = number of hectares per tractor; SNM = percent area where farm machinery not used; NTE = percent number of landholdings; and X = average size of landholding in hectares, for each region, as percent of the total.

The total number of tractors in Mexico has been increasing at an average annual rate of approximately 3.9%, while in the United States the number has been decreasing at a rate of approximately 0.6% according to the data presented in Table 15.

Table 16 shows the number of tractors per hectare in both countries. In Mexico the number of tractors per hectare has been increasing at an average annual rate of 3.4%, and in the United States it has been decreasing at about 2% a year. However, because this data does not take into account the size of tractors used, it can be misleading.

Table 15. Total Number of Tractors in Use, and Index for Mexico (M6) and the United States (U6), 1969-1978 (1969-1971=100)

| Year | Mexico Tractors[a] (x $10^3$) | Mexico M6 | Mexico % change | United States Tractors[a] (x $10^6$) | United States U6 | United States % change |
|---|---|---|---|---|---|---|
| 1969 | (110.0) | 95.6 | | (4.64) | 101.8 | |
| 1970 | 115.2 | 100.1 | 4.8 | 4.56 | 100.1 | -1.7 |
| 1971 | 120.0 | 104.3 | 4.1 | 4.47 | 98.1 | -2.0 |
| 1972 | 126.0 | 109.5 | 5.0 | 4.39 | 96.3 | -1.8 |
| 1973 | 130.0 | 113.0 | 3.2 | 4.38 | 96.0 | -0.2 |
| 1974 | 135.0 | 117.3 | 3.8 | 4.27 | 93.8 | -2.4 |
| 1975 | 140.0 | 121.7 | 3.7 | 4.11 | 90.2 | -3.8 |
| 1976 | 140.0 | 121.7 | 0.0 | 4.11 | 90.2 | 0.0 |
| 1977 | 150.0 | 130.4 | 7.1 | 4.37 | 95.9 | 6.4 |
| 1976 | 155.0 | 134.7 | 3.3 | 4.37 | 95.9 | 0.0 |
| Mean | 132.1 | 114.8 | 4.0 | 4.37 | 95.8 | -0.6 |
| Std. dev. | 14.7 | 1.1 | 2.0 | 0.17 | 2.9 | 2.9 |

Source: F.A.O., Production Yearbook, various issues.
Note: Values in parenthesis are linearly trended.

[a]Tractors not differentiated by size or capacity.

Table 16. Number of Tractors per Hectare of Arable Land, and Index, for Mexico and the United States, 1969-1978 (1969-1971=100)

| Year | Mexico Tractors/ha. (x $10^{-4}$) | Mexico Index | Mexico % change | United States Tractors/ha. (x $10^{-4}$) | United States Index | United States % change |
|---|---|---|---|---|---|---|
| 1969 | 43 | 95.5 | | 245 | 102.9 | |
| 1970 | 45 | 100.0 | 4.6 | 240 | 100.8 | -2.0 |
| 1971 | 47 | 104.4 | 4.4 | 229 | 96.2 | -4.6 |
| 1972 | 50 | 111.1 | 6.4 | 228 | 95.8 | -0.4 |
| 1973 | 51 | 113.3 | 2.0 | 218 | 91.6 | -4.4 |
| 1974 | 53 | 117.8 | 3.9 | 208 | 87.4 | -4.6 |
| 1975 | 53 | 117.8 | 0.0 | 198 | 83.2 | -4.8 |
| 1976 | 54 | 120.0 | 1.9 | 196 | 82.4 | -1.0 |
| 1977 | 57 | 126.7 | 5.6 | 206 | 86.6 | 5.1 |
| 1978 | 58 | 129.0 | 1.8 | 203 | 85.3 | -1.5 |
| Mean | 51 | 113.6 | 3.4 | 217 | 91.2 | -2.0 |
| Std. dev. | 5 | 1.6 | 4.0 | 18 | 3.3 | 4.0 |

Source: Tables 15 and 6.

Productivity Measures. Measurement of machinery productivity was done in the same fashion as for the previous inputs analyzed. Results are shown in Table 17 and depicted in Figure 9 for both Mexico and the United States.

Table 17. Productivity of Machinery for Mexico (MPM) and the United States (MPU), 1969-1978

| Year | Mexico MPM[a] | % change | United States MPU[b] | % change |
|---|---|---|---|---|
| 1969 | 100.4 | | 96.3 | |
| 1970 | 100.0 | -0.4 | 96.9 | 0.6 |
| 1971 | 100.7 | 0.7 | 106.0 | 9.4 |
| 1972 | 97.7 | -3.0 | 108.0 | 1.9 |
| 1973 | 97.3 | -0.4 | 110.4 | 2.2 |
| 1974 | 98.0 | 0.7 | 114.1 | 3.4 |
| 1975 | 92.9 | -5.3 | 125.3 | 9.8 |
| 1976 | 92.9 | 0.0 | 129.7 | 3.5 |
| 1977 | 94.3 | 1.6 | 127.2 | -1.9 |
| 1978 | 97.2 | 3.1 | 125.1 | -1.6 |
| Mean | 97.1 | -0.3 | 113.9 | 3.0 |
| Std. dev. | 2.0 | 2.5 | 3.1 | 4.2 |

Source: Tables 3 and 15.

[a] MPM = ((M1/M6) x 100)

[b] MPU = ((U1/U6) x 100)

It is interesting to note, from both the figure and the table, the great contrast that exists between productivity of this resource for Mexico and for the United States. The United States had great increases during the periods 1970-1971 and 1974-1975. For Mexico, productivity decreased through the years, especially from 1971 to 1973 and from 1974 to 1975.

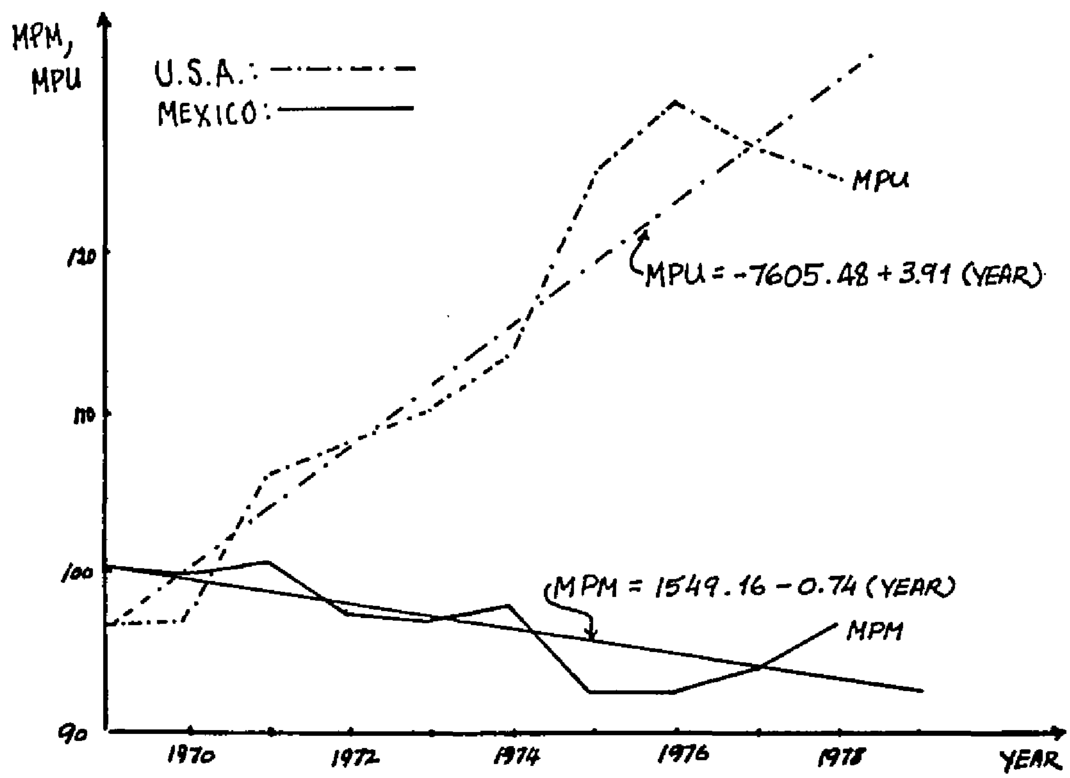


Figure 9. Productivity of machinery for Mexico (MPM) and the United States (MPU), 1969-1978.

Source: Table 17.

## Summary of Productivity Measures

This section presents a summary of the analyses on productivity done on each of the selected inputs. Table 18 presents a summary of results obtained. It makes a comparison with the results obtained for the United States.

Table 18. Summary of Productivity Results for Mexico and the United States

| Input | Mexico | United States |
|---|---|---|
| 1. Land | | |
| Period | 1967-1979 | 1967-1979 |
| Index[a] | Increasing | Increasing |
| Mean[b] | 2.4 | 0.5 |
| 2. Agricultural Labor | | |
| Period | 1967-1979 | 1967-1979 |
| Index[a] | Increasing | Increasing |
| Mean[b] | 1.9 | 6.2 |
| 3. Fertilizer | | |
| Period | 1967-1978 | 1967-1978 |
| Index[a] | Decreasing | Decreasing |
| Mean[b] | -4.7 | -1.3 |
| 4. Machinery | | |
| Period | 1969-1978 | 1969-1978 |
| Index[a] | Decreasing | Increasing |
| Mean[b] | -0.3 | 3.0 |

[a]Refers to productivity index $M1/M_i$ or $U1/U_i$, i = 3, 4, 5, 6.

[b]Refers to average annual rate of change.

From Table 18 we can see that the productivity of land increased five times faster in Mexico than in the United States. The productivity of labor, on the other hand, increased for the United States about three times faster than Mexico. While no comparisons can be made for machinery, fertilizer productivity decreased 3.6 times faster in Mexico than it did in the United States.

# CHAPTER 5

# ANALYSIS OF AGRICULTURAL PRODUCTION: STATE AND LOCAL LEVELS

An objective of this thesis is to view agriculture at the state and local levels. The state of Sonora was already described in chapter 3. In this chapter the focus is exclusively on agricultural production in Sonora. Comparisons are made with agricultural production of Arizona.

At the local level, the focus is centered on the Yaqui Valley, an agricultural producing area in Sonora; and comparisons are made to Pinal County, an agricultural area in Arizona.

## Assessment of Agricultural Production

In assessing agricultural production in Sonora, an increase in the use of modern technology was considered a sign of development. Modern technology comprises use of fertilizers, pesticides, herbicides, and machinery, which are readily quantifiable, and better management practices, education, health, et cetera, which are more difficult to measure. The above factors together increase production, subject to environmental and climatological factors inherent in agriculture.

### Yield per Land Area

State Level. Yield per land area was measured from official data, and a yield index was calculated. The index of yield per land area included the yields of ten crops for both Sonora and Arizona. The crops included for Sonora were alfalfa, sesame, safflower, barley, flax, corn, sorghum, soy beans, wheat, and cotton. For Arizona the crops included were cotton, alfalfa, wheat, barley, corn, sorghum, safflower, other hay, sugar beets, and lettuce. A yield index was calculated for each crop, taking the average yield of 1969-1971 as the base. Then, for each year, the yield index was summed and divided by the number of crops so that we obtained then the average yield index of ten crops for that year in particular. One of the disadvantages of using this yield index is the equal weight given to each crop which does not show a particular advantage that a given area could have in the production of a particular crop. Moreover, the crops being compared are not all the same in both areas. Therefore, in addition to these "ten-crop" yield indices, others were calculated for wheat and for cotton for both Sonora and Arizona. Wheat and cotton are both important and well-established crops in both regions.

Table 19 presents the ten-crop average yield index per area of land for both Sonora and Arizona; and Tables 20 and 21 present the yield index for wheat and yield index for cotton for both states.

Table 19 shows that the mean yield index per area of land for Sonora was 101.9 and for Arizona, 116.7; on the average, yields were about 13% higher in Arizona. Yields were also increasing 2.6 times faster in Arizona when compared to Sonora.

Table 19. Ten-Crop Average Yield Index per Area of Land for Arizona and Sonora, 1969-1980 (1969-1971=100)

| Year | Sonora Index | Sonora % change | Arizona Index | Arizona % change |
|---|---|---|---|---|
| 1969 | 92.1 | | 98.5 | |
| 1970 | 102.9 | 11.7 | 96.0 | -2.5 |
| 1971 | 105.0 | 2.0 | 105.2 | 10.0 |
| 1972 | 99.5 | -5.2 | 106.6 | 1.3 |
| 1973 | 103.9 | 4.4 | 103.1 | -3.3 |
| 1974 | 103.9 | 0.0 | 109.9 | 6.6 |
| 1975 | 108.2 | 4.1 | 108.0 | -1.7 |
| 1976 | 103.5 | -4.3 | 127.7 | 18.2 |
| 1977 | 98.9 | -4.4 | 133.8 | 4.8 |
| 1978 | 97.6 | -1.3 | 136.4 | 1.9 |
| 1979 | 101.4 | 4.0 | 132.6 | -2.8 |
| 1980 | 106.3 | 4.8 | 142.2 | 7.2 |
| Mean | 101.9 | 1.4 | 116.7 | 3.6 |
| Std. dev. | 4.1 | 5.1 | 4.8 | 6.6 |

Source: Tables B.1 and B.2, Appendix B.

Table 20. Wheat Yield Index per Area of Land for Arizona and Sonora, 1969-1980 (1969-1971=100)

| Year | Sonora Index | Sonora % change | Arizona Index | Arizona % change |
|---|---|---|---|---|
| 1969 | 98 | | 93 | |
| 1970 | 101 | 3.1 | 104 | 11.8 |
| 1971 | 101 | 0.0 | 102 | -1.9 |
| 1972 | 93 | -7.9 | 101 | -1.0 |
| 1973 | 114 | 22.6 | 102 | 1.0 |
| 1974 | 114 | 0.0 | 98 | -3.9 |
| 1975 | 130 | 14.0 | 106 | 8.2 |
| 1976 | 119 | -8.5 | 113 | 6.6 |
| 1977 | 104 | -12.6 | 108 | -4.4 |
| 1978 | 114 | 9.6 | 106 | -1.8 |
| 1979 | 130 | 14.0 | 115 | 8.5 |
| 1980 | 117 | -10.0 | 121 | 5.2 |
| Mean | 111.2 | 2.2 | 105.8 | 2.6 |
| Std. dev. | 7.8 | 11.6 | 4.0 | 5.6 |

Source: Tables B.1 and B.2, Appendix B.

Table 21. Cotton Yield Index per Area of Land for Arizona and Sonora, 1969-1980 (1969-1971=100)

| Year | Sonora Index | Sonora % change | Arizona Index | Arizona % change |
|---|---|---|---|---|
| 1969 | 97 | | 109 | |
| 1970 | 101 | 4.1 | 96 | -11.9 |
| 1971 | 101 | 0.0 | 95 | -1.0 |
| 1972 | 97 | -4.0 | 112 | 17.9 |
| 1973 | 134 | 38.0 | 113 | 0.9 |
| 1974 | 126 | -6.0 | 131 | 15.9 |
| 1975 | 122 | -3.2 | 110 | -16.0 |
| 1976 | 146 | 19.7 | 128 | 16.4 |
| 1977 | 134 | -8.2 | 109 | -14.8 |
| 1978 | 138 | 3.0 | 105 | -3.7 |
| 1979 | 138 | 0.0 | 116 | 10.5 |
| 1980 | 142 | 2.9 | 121 | 4.3 |
| Mean | 123 | 4.2 | 112 | 1.7 |
| Std. dev. | 7.7 | 13.4 | 8.8 | 12.5 |

Source: Tables B.1 and B.2, Appendix B.

The results obtained from using individual crop yield indices differ from those obtained from the ten-crop index. While the average yield index for Arizona increased 2.6 times faster than the index for Sonora, for the 1969-1980 period, the wheat yield index for Arizona increased only 1.2 times faster than the Sonoran index, for the same period. The cotton yield index for Sonora, on the other hand, increased 2.5 times faster than the yield index for Arizona.

The use of individual crop yield indices shows that Arizona has advantage over Sonora in the production of wheat, and that Sonora has advantage over Arizona in the production of cotton. These distinctions could not be pointed out by using the ten-crop yield index.

Local Level. The yield index per land area was calculated in the same way as it was calculated for the state level. As in the state level, yield indices for wheat and cotton will also be presented.

Table 22 presents the ten-crop yield index for both the Yaqui Valley and Pinal County.

Table 22. Ten-Crop Average Yield Index per Area of Land for Pinal County, Arizona, and Yaqui Valley, Sonora, 1969-1980 (1969-1971=100)

| | Yaqui Valley | | Pinal County | |
|---|---|---|---|---|
| Year | Index | % change | Index | % change |
| 1969 | 92.7 | | 103.3 | |
| 1970 | 102.4 | 10.5 | 95.4 | -7.6 |
| 1971 | 104.9 | 2.4 | 101.3 | 6.2 |
| 1972 | 96.6 | -7.9 | 99.9 | -1.4 |
| 1973 | 101.9 | 5.5 | 101.5 | 1.6 |
| 1974 | 106.6 | 4.6 | 110.0 | 8.4 |
| 1975 | 101.0 | -5.2 | 108.5 | -1.4 |
| 1976 | 96.5 | -4.4 | 123.3 | 13.6 |
| 1977 | 99.0 | 2.6 | 113.2 | -8.2 |
| 1978 | 100.6 | 1.6 | 107.4 | -5.1 |
| 1979 | 97.8 | -2.8 | 105.4 | -1.9 |
| 1980 | 108.5 | 10.9 | 125.0 | 18.6 |
| Mean | 100.7 | 1.6 | 107.8 | 2.1 |
| Std. dev. | 4.4 | 6.2 | 5.8 | 8.7 |

Source: Tables B.3 and B.4, Appendix B.

The results obtained at the local level seem to be consistent with those at the state level. Although yields in the Yaqui Valley were increasing during the seventies, this increase was 1.3 times lower than the increase in yields achieved by Pinal County, Arizona.

Tables 23 and 24 present the yield indices for wheat and cotton respectively, for the Yaqui Valley, Sonora, and Pinal County, Arizona.

Table 23. Wheat Yield Index per Area of Land for Yaqui Valley, Sonora, and Pinal County, Arizona, 1969-1980 (1969-1971=100)

| | Yaqui Valley | | Pinal County | |
|---|---|---|---|---|
| Year | Index | % change | Index | % change |
| 1969 | 98.8 | | 88.0 | |
| 1970 | 97.5 | -1.3 | 108.4 | 23.2 |
| 1971 | 103.7 | 6.4 | 103.6 | -4.4 |
| 1972 | 92.5 | -10.8 | 103.6 | 0.0 |
| 1973 | 108.7 | 17.5 | 106.8 | 3.1 |
| 1974 | 117.2 | 7.8 | 98.8 | -7.5 |
| 1975 | 132.3 | 12.9 | 111.6 | 13.0 |
| 1976 | 122.8 | -7.2 | 118.0 | 5.7 |
| 1977 | 105.7 | -13.9 | 111.6 | -5.4 |
| 1978 | 112.0 | 6.0 | 110.8 | -0.7 |
| 1979 | 126.7 | 13.1 | 117.4 | 6.0 |
| 1980 | 115.3 | -9.0 | 122.0 | 3.9 |
| Mean | 111.1 | 2.0 | 108.4 | 3.4 |
| Std. dev. | 8.4 | 10.9 | 5.3 | 8.8 |

Source: Tables B.3 and B.4, Appendix B.

Table 24. Cotton Yield Index per Area of Land for Yaqui Valley, Sonora, and Pinal County, Arizona, 1969-1980 (1969-1971=100)

| | Yaqui Valley | | Pinal County | |
|---|---|---|---|---|
| Year | Index | % change | Index | % change |
| 1969 | 85.6 | | 105.6 | |
| 1970 | 106.8 | 24.8 | 100.7 | -4.6 |
| 1971 | 107.5 | 0.6 | 93.6 | -7.0 |
| 1972 | 98.2 | -8.6 | 110.3 | 17.8 |
| 1973 | 123.2 | 25.4 | 114.4 | 3.7 |
| 1974 | 128.6 | 4.1 | 120.4 | 5.2 |
| 1975 | 126.0 | -2.0 | 87.0 | -27.7 |
| 1976 | 127.9 | 1.5 | 117.6 | 35.2 |
| 1977 | 135.1 | 5.6 | 111.5 | -5.2 |
| 1978 | 144.6 | 7.0 | 96.8 | -13.2 |
| 1979 | 116.9 | -19.2 | 112.7 | 16.4 |
| 1980 | 141.4 | 21.0 | 118.5 | 5.1 |
| Mean | 120.2 | 5.5 | 107.4 | 2.3 |
| Std. dev. | 8.3 | 13.8 | 9.5 | 16.9 |

Source: Tables B.3 and B.4, Appendix B.

For wheat, the yields in Pinal County increased 1.7 times faster than the yields in the Yaqui Valley. However, the yields of cotton increased 2.4 times faster in the Yaqui Valley than in Pinal County, for the period 1969-1980. Again, the results obtained at the local level show themselves to be consistent with those results obtained at the state level.

## Agricultural Labor Force

Although the data available make it difficult to make an in-depth analysis with respect to agricultural labor force in the state of Sonora, it is nevertheless sufficient to assess some generalized trends.

From the little data available, the total population of Sonora increased from the 1960 census to 1970 from 783,378 to 1,098,720 inhabitants, an increase of 40% over the 10-year period, or 4% annual rate. In 1960, 57% of the male economically active population worked on agricultur; by 1970, this percentage decreased to 44.1%. There was an actual decrease of 13.1% in the number of male persons engaged in agriculture for the period 1960-1970. The percentage of females engaged in agriculture (economically active) decreased from 37.1% in 1960 to 12.7% in 1970, and the actual decrease in number was 60% for the same period. These figures show a decreasing trend of people engaged in agriculture, both relative and absolute, in the state of Sonora. The data on population are presented in Appendix B.

## Inputs of Production

### State Level

Among the inputs for which data are readily available at the state level, for Sonora, are improved seeds use and fertilizer consumption. Data on machinery use are more difficult to obtain; therefore, the inclusion of machinery use in the analysis will be brief.

The amount of improved seeds produced in Sonora has increased significantly for various crops, in the period 1969-1978. The most important crops for which improved seeds are produced in Sonora are presented in Table 25.

Table 25. Production of Improved Seeds, Sonora, 1969-1978

| | Wheat | | Cotton | | Safflower | | Soy Beans | |
|---|---|---|---|---|---|---|---|---|
| Year | Tons | % chg. | Tons | % chg. | Tons | % chg. | Tons | % chg. |
| 1969 | 6760 | | 2312 | | 676 | | n.a. | |
| 1970 | 8278 | 22.4 | 2669 | 15.4 | 814 | 20.4 | 284 | |
| 1971 | 34506 | 316.8 | 4496 | 69.4 | 1647 | 102.3 | 5873 | 1968.0 |
| 1972 | 42668 | 23.6 | 2537 | -43.6 | 1056 | -35.9 | 4010 | -31.7 |
| 1973 | 33038 | -22.6 | 3465 | 36.6 | 801 | -24.1 | 8516 | 112.4 |
| 1974 | 46388 | 40.4 | 771 | -77.7 | 2354 | 193.9 | 9399 | 10.4 |
| 1975 | 89395 | 92.7 | 571 | -25.9 | 3776 | 60.4 | 10214 | 8.7 |
| 1976 | 61099 | -31.6 | 1713 | 200.0 | 2098 | -44.4 | 3944 | -61.4 |
| 1977 | 58260 | -4.6 | 2317 | 35.2 | 2523 | 20.2 | 5865 | 48.7 |
| 1978 | 64654 | 11.0 | 4323 | 86.6 | 5544 | 119.7 | 10978 | 87.2 |
| Mean | 44505 | 49.8 | 2517 | 32.8 | 2129 | 45.8 | 6565 | 267.8 |
| S.D. | 25519 | 106.6 | 1319 | 82.1 | 1548 | 80.5 | 3508 | 689.4 |

Source: SARH, Prontuario Estadistico Sonora Agropecuario, Dic. 1979.
Note: n.a. = not available.

The most significant increases in production of improved seens have been achieved in wheat and soy beans, followed by safflower and cotton. Improved seeds for corn, potatoes, garbanzo, and sesame are also produced in Sonora. For the most part, improved seeds are used within the state; however, in the case of wheat, large amounts are exported overseas (SARH, Prontuario Estadistico Sonora Agropecuario, p. 160).

The consumption of fertilizer in Sonora increased at a 3% average annual rate for the period 1975-1978. The land area where fertilizers were used increased at a 5.2% average annual rate for the same period. However, the quantity of fertilizer applied per hectare decreased at a 0.4% average annual rate. These figures are presented in Table 26.

Table 26. Fertilization in Sonoran Agriculture, 1975-1978

| Year | Area fertilized (hectares) | % chg. | Total fertilizer consumption (M tons) | % chg. | Fertilizer consumption (Kg/ha) | % chg. |
|---|---|---|---|---|---|---|
| 1975 | 137454 | | 567581 | | 242.2 | |
| 1976 | 147501 | 7.3 | 629251 | 10.9 | 234.4 | -3.2 |
| 1977 | 134544 | -8.8 | 504599 | -19.8 | 266.6 | 13.7 |
| 1978 | 148100 | 10.1 | 628132 | 24.5 | 235.8 | -11.6 |
| Mean | 141900 | 2.9 | 582391 | 5.2 | 244.8 | -0.4 |

Source: SARH, Prontuario Estadistico Sonora Agropecuario, Dic. 1979.

In 1978, 98.7% of Sonora's cultivated land was farmed exclusively by tractors. The number of tractors in the state was 8285, second only to the state of Sinaloa, which had 10419 tractors in the same year. The average size of land farmed with tractors, in 1978, was 70.5 hectares (SARH, DGEA 1979).

Local Level

The production of improved seeds in the Yaqui Valley has been, as on the state level, for several crops. Among the most important are wheat, safflower, corn, and soy beans. From Table 27 we see that the production of improved seeds increased at an average annual rate of 46.5% for safflower and 37.4% for corn. For wheat and soy beans production of improved seeds increased at an annual rate of 24.9% and 24.7% respectively.

Table 27. Production of Improved Seeds, Yaqui Valley, Sonora, 1971-1978

| | Wheat | | Safflower | | Corn | | Soy Beans | |
|---|---|---|---|---|---|---|---|---|
| Year | Tons | % chg. | Tons | % chg. | Tons | % chg. | Tons | % chg. |
| 1971 | 17066 | | 909 | | 1208 | | 5873 | |
| 1972 | 34567 | 102.5 | 770 | -15.3 | 1763 | 46.0 | 4010 | -31.7 |
| 1973 | 26056 | -24.6 | 570 | -26.0 | 427 | -76.0 | 8516 | 112.4 |
| 1974 | 37634 | 44.4 | 1302 | 128.4 | 1500 | 251.3 | 8937 | 4.9 |
| 1975 | 67485 | 79.3 | 2981 | 129.0 | 3664 | 144.3 | 9938 | 11.2 |
| 1976 | 46319 | -31.4 | 1205 | -60.0 | 3699 | 1.0 | 3889 | -60.9 |
| 1977 | 40292 | -13.0 | 1328 | 10.2 | 928 | -75.0 | 5286 | 35.9 |
| 1978 | 47283 | 17.4 | 3440 | 159.0 | 654 | -29.5 | 10644 | 101.4 |
| Mean | 39588 | 24.9 | 1563 | 46.5 | 1730 | 37.4 | 7136 | 24.7 |
| S.D. | 15131 | 52.4 | 1057 | 89.4 | 1278 | 121.5 | 2689 | 64.3 |

Source: SARH, Prontuario Estadistico Sonora Agropecuario, Dic. 1979.

Data for 1972-1980 (see Table B.5, Appendix B) show that the use of improved seeds in the Yaqui Valley is a common practice, except perhaps for corn, which in the period 1972-1980, 10% of the land planted with corn did not use improved seeds.

Fertilizer usage is also a generalized practice among farmers of the Yaqui Valley, and it is used on more than 70% of the cultivated land. Figures on the use of fertilizers and improved seeds are presented in Table 28.

Table 28. Use of Fertilizer and Improved Seeds, Yaqui Valley, Sonora

| Crop | Land[a] using improved seeds (as % of total arable land) | Land[b] using fertilizer (as % of total arable land) |
|---|---|---|
| Alfalfa | 100 | 71 |
| Corn | 90 | 82 |
| Cotton | 100 | 98 |
| Flax | 100 | 93 |
| Safflower | 100 | 93 |
| Sesame | 96 | 98 |
| Sorghum | 100 | 84 |
| Soy Beans | 100 | 94 |
| Wheat | 100 | 95 |

Source: Tables B.6, B.7, and B.8, Appendix B.

[a]1972-1980 average.

[b]1965-1980 average.

Data on the use of farm tractors for the Yaqui Valley is presented in Table 29.

Table 29. Number of Hectares Farmed with Tractors, Yaqui Valley, Sonora, 1964-1978

| Year | Hectares |
|---|---|
| 1964-1968 | 202383 |
| 1969 | 216115 |
| 1970-1974 | 214561 |
| 1975 | n.a. |
| 1976 | 213953 |
| 1977 | 214703 |
| 1978 | 226555 |

Source: SARH, DGEA, various issues.

The amount of land farmed with tractors in the Yaqui Valley increased from 1964 to 1978. Data from the SARH show that the total amount of arable land in the Yaqui Valley (Irrigation District No. 41) was around 225,000 hectares in 1977. From the data presented in Table 29 and this information, we can conclude that the Yaqui Valley is 100% farmed with tractors.

## Measuring Input Usage from Budgets

Crop budgets for Pinal County and the Yaqui Valley were compared for wheat and cotton, and the level of usage of various inputs was estimated. The variation in input usage measured from budgets has not been great over the past five years; therefore, the latest data available, i.e., data from 1981 budgets, will be used.

Some of the input quantities per hectare budgeted for wheat are presented in Table 30 for both the Yaqui Valley and Pinal County.

Table 30. Selected Inputs Budgeted for Wheat, Pinal County, Arizona, and Yaqui Valley, Sonora, 1981

| Input | Pinal County (quantities per hectare) | Yaqui Valley (quantities per hectare) |
|---|---|---|
| Fertilizer | 205 kg of N<br>53.8 kg of $P_2O_5$ | 150 kg of N<br>46 kg of $P_2O_5$ |
| Seed | 168 kg | 130 kg |
| Herbicides | | Dacamine-4D, 3/4 lt |
| Insecticides | | Parathion methyl 720, 2 lt<br>Endrin 16, 2 lt |
| Water | 3649 cubic meters | 7660 cubic meters |

Source: 1981 Arizona Field Crop Budgets, Pinal County, Cooperative Extension Service, The University of Arizona, January 1981; and unpublished crop budgets, F.I.R.A., Residencia Estatal Sur de Sonora.

The expected average per-hectare yield of wheat was 4.7 metric tons for the Yaqui Valley and 5.2 metric tons for Pinal County, the expected yield being 11% higher in Pinal County.

Pinal wheat farmers applied 37% more nitrogen and 17% more $P_2O_5$ per hectare than farmers in the Yaqui Valley. In Pinal County 0.05 kilos of nutrients are used to produce one kilo of wheat, whereas in the Yaqui Valley 0.04 kilos of nutrients are used. The amount of seed per hectare used in Pinal County was 29.2% higher than the amount used in the Yaqui Valley.

Underground water is the source of irrigation water for Pinal County, and surface water is used in the Yaqui Valley for irrigation purposes. The different sources of water for the two local areas account for the differences in the amount used because surface water is available to the Yaqui Valley farmer at a much lower cost than groundwater is available to the Pinal County farmer.

The wheat budget for Pinal County does not account for the use of herbicides and insecticides. In the Yaqui Valley, 3/4 liters of herbicides are budgeted, and 4 liters of insecticides.

The cost per hectare of selected budgeted inputs used in wheat, and the percentage they represent of the total budgeted costs, are presented in Table 31 for both local areas.

From Table 31 we can see that, excluding water, the costs per hectare budgeted for fertilizer, seeds, herbicides, and insecticides for both regions are not very far apart when compared as percentage of total budgeted costs.

Table 31. Cost per Hectare of Selected Inputs Budgeted for Wheat, Pinal County, Arizona, and Yaqui Valley, Sonora, 1981

| | Pinal County | | Yaqui Valley | |
|---|---|---|---|---|
| | Budgeted Cost (U.S. dlls.) | % of Total Budgeted Cost | Budgeted Cost[a] (U.S. dlls.) | % of Total Budgeted Cost |
| Fertilizer | 109.22 | 12 | 60.57 | 11 |
| Seed | 88.66 | 10 | 44.36 | 8 |
| Herbicides | | | 10.24 | 2 |
| Insecticides | | | 9.38 | 2 |
| Water | 177.14 | 19 | 65.05 | 12 |

Source: 1981 Arizona Field Crop Budgets, Pinal County, Cooperative Extension Service, The University of Arizona, January 1981; unpublished budgets, F.I.R.A., Residencia Estatal Sur de Sonora; and Federal Reserve Bulletin, various issues.

[a]The exchange rate used was $0.042655 U.S. dollars per Mexican peso, and corresponds to the average exchange rate from September 1980-May 1981, the wheat cycle in the Yaqui Valley.

Amounts of selected inputs budgeted for cotton for Pinal County and the Yaqui Valley are presented in Table 32.

The expected average cotton yield per hectare was 1.8 metric tons for Pinal County and 2.8 tons for the Yaqui Valley. The expected average yield includes both lint and seed. The amount of nitrogen used by farmers in the Yaqui Valley was 23% less than the amount applied by the farmers in Pinal County. And the amount of $P_2O_5$ used in the Yaqui Valley was 11% less than the amount used in the Pinal County area. From the data obtained it is calculated that it takes 0.11 kilos of nutrients in Pinal County to obtain one kilo of cotton, whereas it only takes 0.06 kilos in the Yaqui Valley. This difference may be due to differences in agricultural practices used, different cotton varieties, and differences in soils.

Table 32. Selected Inputs Budgeted for Cotton, Pinal County, Arizona, and Yaqui Valley, Sonora, 1981

| Input | Pinal County[a] (quantities per hectare) | | Yaqui Valley (quantities per hectare) | |
|---|---|---|---|---|
| Fertilizer | 148 kg of N | | 120 kg of N | |
| | 44.5 kg of $P_2O_5$ | | 40 kg of $P_2O_5$ | |
| Seed | 13.5 kg | | 40 kg | |
| Herbicides | Treflan | 1.8 l. | | |
| | Caparol | 8.1 l. | Labor budgeted | |
| | Roundup | 0.44l. | | |
| Insecticides | Methyl Parathion | 16.4 l. | Methyl Parathion 720 | 1.0 l. |
| | Fundal Galercon | 0.6 l. | Ethyl Parathion 900 | 0.87 l. |
| | Ambush | 0.7 l. | Nuvacron 60 | 0.78 l. |
| | Pounce | 0.4 l. | Endrin | 1.0 l. |
| | Lannate | 2.3 l. | Lannate | 0.3 l. |
| | | | Azodrin 5 | 0.6 l. |
| Defoliant | Sodium chlorate | 37.4 l. | Budgeted, but product or amount applied not specified. | |
| Water | 6168 cubic meters | | 8000 cubic meters | |

Source: 1980 Arizona Field Crop Budgets, Pinal County, January 1980; and unpublished budgets, F.I.R.A., Residencia Estatal Sur de Sonora.

[a]Quantities converted from English system to metric.

With respect to seed, the Yaqui Valley farmer used almost 200% more seed per hectare than the amount used by the Pinal County farmer. Again, different agricultural practices as well as varieties of cotton used may account for these differences.

Pinal County farmers used five different chemical insecticides, and the total amount applied per hectare was 20.44 liters; the Yaqui Valley used six different chemical substances with a total amount of

4.55 liters applied per hectare. Neither the product nor the amount of defoliant applied per hectare was specified for the Yaqui Valley. The cost of defoliant was, however, included in the budget, and it is presented in Table 33.

Herbicides were not budgeted for the Yaqui Valley; instead, labor for weeding was included. These costs are also included in Table 33.

The water used per hectare was 8000 cubic meters for the Yaqui Valley and 6167.5 for Pinal County, Pinal County using 30% less water per hectare than the Yaqui Valley. The reasons for these differences were mentioned above.

Table 33 shows the cost per hectare as well as the percentage of the total budgeted costs for selected inputs for both local areas.

Table 33. Cost per Hectare of Selected Inputs Budgeted for Cotton, Pinal County, Arizona, and Yaqui Valley, Sonora, 1980

| | Pinal County | | Yaqui Valley | |
|---|---|---|---|---|
| Input | Budgeted cost (U.S. dlls.) | % budgeted cost | Budgeted cost[a] (U.S. dlls.) | % budgeted cost |
| Fertilizer | 83.82 | 5 | 51.24 | 5 |
| Seed | 8.00 | 1 | 34.94 | 3 |
| Insecticides | 145.24 | 8 | 45.64 | 4 |
| Defoliant | 13.76 | 1 | 17.95 | 2 |
| Weeding | | | | |
| Herbicides | 39.10 | 5 | | |
| Labor | | | 50.67 | 5 |
| Water | 314.85 | 18 | 55.91 | 5 |

Source: 1980 Arizona Field Crop Budgets, Pinal County, January 1980; unpublished crop budgets, F.I.R.A., Residencia Estatal Sur de Sonora; and Federal Reserve Bulletin, various issues.

[a]Exchange rate used was $0.043679 U.S. dollars per Mexican peso. Corresponds to the average exchange rate for January-August 1980, the cotton cycle in the Yaqui Valley.

Excluding water, selected inputs of production in cotton account for 20% of the total budgeted costs in Pinal County and 14% in the Yaqui Valley.

It must be kept in mind that these figures come from budgeted inputs and that they vary from farmer to farmer. In general, the same inputs were used in both regions, although in varying amounts. As was mentioned before, no herbicides were budgeted for the Yaqui Valley; nevertheless, in Ciudad Obregon, Sonora, the center city for the valley, at least 11 firms sell all kinds of chemical products for agriculture, including the same herbicides and defoliants used in Pinal County. The Sonoran farmer, then, would seem to have the choice of using chemicals or labor or both as production inputs.

## Assessing Input Usage from Survey Results

To support the data obtained from official sources, a questionnaire was applied to farmers from the Yaqui Valley. To obtain a group of farmers that could be considered representative of the whole valley, their selection was random; it included private property owners as well as ejidatarios. One hundred and nineteen farmers were surveyed (a copy of the questionnaire is presented in Appendix C). The questionnaire was divided into four major parts. Part one deals with the use of herbicides by local farmers; part two with the use of fertilizers; part three with the use of machinery; and part four with the harvesting of cotton. Part four was included in the hope that the results obtained would yield insight into capital-labor substitution. The results were as follows:

For part one, 99% of the farmers surveyed acknowledged using herbicides in wheat and 88% in cotton. Fifty-one percent considered that the use of herbicides in wheat had increased in the past 10 years, and 47% considered that it had remained constant during this period. For cotton, 50% felt the use of herbicides had increased and 50% thought it had remained constant. Weeds can be controlled by mechanical means, through cultivation, at early stages of growth of cotton, and perhaps this is one reason why more farmers used herbicides in wheat as compared to cotton. The reasons given most often for increased use of herbicides was the low cost of herbicides compared with the cost of labor. The second reason given was increased weeds. Most farmers surveyed applied their herbicides using both surface and aereal means. The majority of farmers who did not use herbicides for weed control used labor; others used a combination of mechanical and manual means. Question 8 in the questionnaire, regarding the number of hours of labor used per hectare for weed control, was omitted in this analysis because its formulation led to misleading answers.

The results of part two are as follows: All the farmers surveyes applied fertilizer for both cotton and wheat; 61% thought that the use of fertilizer for both cotton and wheat had increased in the past 10 years and 38% thought it had remained constant. The three reasons most often given for using fertilizer were that production increased after using fertilizer, that the extension service recommended its use, and that poor soils due to continued exploitation had made the use of fertilizer necessary.

In part three, some of the questions were not understood; consequently, some of the answers did not make sense. The two cultural practices most mentioned by farmers in which they did not use machinery were weeding and irrigation. One hundred percent of the farmers thought that in the past 10 years the use of machinery had increased for farm operations. Reasons given for this increased use were that its use is efficient and fast, and that its use is encouraged by the government's farm mechanization program. Ninety-six percent of the farmers felt that in the last 10 years the use of machinery for labor had increased; the rest felt it had remained constant.

The last part of the questionnaire, regarding the harvesting of cotton, resulted in some interesting answers. The harvesting of cotton in the Yaqui Valley is done either by hand or mechanically. Labor used in cotton picking is for the most part imported from southern states of the country, although local labor is also employed. To a greater extent, cotton harvesting by machines is done through custom hiring.

Table 34 presents the costs of custom-hired cotton pickers and labor for the Yaqui Valley, Sonora.

Table 34. Cost of Cotton Harvesting, Custom Hired or Labor, Yaqui Valley, Sonora, 1980-1982

| | 1980 | (Mexican Pesos per Hectare) | 1981 |
|---|---|---|---|
| Custom Hired | 5500 | | 8500 |
| Labor | | | |
| Harvest | 5432 | | 6425 |
| Transport | 810 | | 810 |
| Personnel[a] | 425 | | 535 |
| | 6667 | | 7770 |

Source: BANAMEX, S.A., unpublished crop budgets.

[a]Field personnel who receive and weigh harvested cotton, pay pickers.

As we can see from Table 35, labor harvesting of cotton has more aspects involved to it than custom-hired harvesting. The cost of custom-hired machines varies according to the supply of machines available to the area as well as the total number of hectares planted with cotton.

Question 18 asked the farmers on what percentage of their land they used cotton picking machinery and on what percentage they used labor for harvesting cotton. The results are displayed in Table 35.

Table 35. Use of Labor and Mechanization for Cotton Harvesting, Yaqui Valley, Sonora, Survey Results, 1981

| Percent of Land, Single Farm Mechanization | Labor | | Number of Responses |
|---|---|---|---|
| 100 | 0 | | 43 |
| 90 | 10 | | 1 |
| 80 | 20 | | 17 |
| 75 | 25 | | 8 |
| 70 | 30 | | 1 |
| 50 | 50 | | 19 |
| 40 | 60 | | 1 |
| 20 | 80 | | 1 |
| 0 | 100 | | 26 |
| | | Total | 117 |

Source: Appendix C.

Farmers who relied more on mechanical harvesting cited as reasons for not hiring labor the bad job that hand pickers do and the scarcity of labor. Other reasons given were the high cost of labor, problems in setting the price per kilogram picked, and problems in transporting laborers to the field. Of those farmers who used mechanical harvesting, 46% said that the quality of mechanically picked cotton decreased very little, and 35% said there was no decrease in quality. Fifty-seven percent said that the quantity of mechanically picked cotton is the same as when it is hand picked, 28% said that there is a slight decrease, and 11% said that the quantity increases. Farmers who used more labor than mechanical means to pick cotton said that their lands were ejidos, therefore they had to create jobs. Another reason they gave was the decrease in the quantity of cotton when machine picked.

Farmers who used a combination of mechanical and labor for cotton picking did so because of reasons of rain and wet fields. The cotton harvesting season in the Yaqui Valley coincides with the rainy season. Unharvested cotton when rained on gets spots which lower its quality, and heavy price discounts are levied at the gin. This is the reason why farmers have to alternate between labor and machinery for harvesting cotton. Other farmers said that they use labor because whatever the machine cannot pick, people can, and they use labor when they have machine failures. Still others used labor because unleveled fields made machine use difficult. Sixty-nine percent of farmers said that there are years when they use more labor than machines because of the low availability of machines, because of rains, and to create jobs; 31% answered negatively to this question.

Eighty-one percent of the farmers answered yes when asked if there were years when they used more mechanical harvesting than labor. Their reasons were that they did so when they were able to hire mechanical harvesters, that they have fewer problems using machines, and that machines are faster and more effective. Nineteen percent answered no to this question. When asked for comments about cotton harvesting in the Yaqui Valley, most answered that it should be 100% mechanized; others said that there should be a balance between labor and machinery; and others said that harvest should be regulated, perhaps referring to increased government participation.

# CHAPTER 6

# SUMMARY AND CONCLUSIONS

## National Level

Mexico is a country of significant contrasts. There are arid zones and humid zones, well-developed agricultural regions as well as regions with traditional, stagnant agriculture. Because of these differences, it is difficult to determine the level of development of Mexican agriculture. Perhaps in analyzing the level of development of Mexican agriculture the concept of dualism proposed by Boeke (1953) can be extended to one sector of the economy. In this case, the agricultural sector of Mexico, a developed and modern sector exists as well as a traditional, underdeveloped sector.

The question of considering a country or a region as developed depends upon the standards on which we choose to base our judgment. The issue of development has been addressed in this study only in relation to agriculture. Economic development, or even economic growth, of Mexico was beyond the scope of this paper. Throughout this paper the behavior of agriculture in the United States is used as a standard of development with which to compare Mexico.

Most modern agricultural production in Mexico takes place in northern irrigation districts. Throughout the years, the government has had a prime role in fostering agricultural development. During the early years, the government invested heavily in irrigation works as well as agricultural credit. More recently, other areas which have received attention are the emphasis on modern input utilization, education, and research.

The results of the research carried out for this paper show that agriculture is becoming less important in its share of gross domestic product. During the seventies it accounted for only 5.9% of the total gross domestic product. In spite of this figure, agricultural production in Mexico has been increasing at an annual rate close to 3%. But the demand imposed on agriculture is heavy. Population in Mexico is growing at a faster rate than agricultural production. This has led to increased importation of food. The best illustration of this situation is the index of per capita agricultural production, which during the period 1967-1979 showed an annual average decrease of 0.4%.

With respect to the inputs used in production, there has been a trend to increased use of modern technology, especially in the irrigated northern part of the country. Arable land increased at an average annual rate of 0.8% for the 1964-1979 period. The productivity of land seems to be increasing when measured by dividing total production by the input being analyzed.

Agricultural labor has been decreasing as a percentage of the total economically active population, and it has been pointed out by some authors that a transfer of labor has been taking place from agriculture to other sectors of the economy. The total number of people engaged in agriculture, however, increased at an annual average rate of 1% for the period 1965-1979. This number is less than the average annual rate of increase of total labor force, which is 3.3% for 1960-1979. The productivity of labor measured using the method mentioned above increased at an annual average rate of 1.9% for 1967-1979.

Fertilizer consumption increased at an average annual rate of 9.3% for 1964-1978. Although the use of fertilizer increased, the amount of fertilizer applied per hectare, when compared with the amount applied in the United States, seemed significantly low. Mexico applied 27.3 kilos per arable hectare compared to 80 kilos applied in the United States; 8.4% annual average rate versus 4.1% for the United States. The productivity of fertilizer decreased for both Mexico and the United States when measured for the period 1967-1978.

In Mexico, the use of machinery in agriculture increased at an annual average rate of 4% compared to a decrease for the United States of 0.6% annually. Unfortunately, these figures are irrelevant for comparison because they take into account only the total number of tractors in each country without regard to the capacity of the machines. So, it could be that farmers in the United States are acquiring fewer machines but with greater capacity. The average productivity of tractors in Mexico decreased at an annual average rate of 0.3%, whereas in the United States it is increasing at an average annual rate of 3%.

## State and Local Levels

The analysis at the state and local levels showed the same trends observed at the national level. Although the data at the state and local levels were not as numerous as the data for the nation, they were sufficiently specific to observe trends and behavior of agriculture.

Unlike labor at the national level, the labor force in Sonora has been decreasing. The percentage of economically active males working in agriculture in 1960 was 57% and decreased to 44.1% in 1970. The number of males working in agriculture decreased at an annual average rate of 1.3% from 1960 to 1970.

The average yields of ten crops, for the period 1969-1980, increased at an annual average rate of 1.4% for Sonora compared to 3.6% for Arizona. The situation is similar at the local level. Average yields of ten crops increased at 1.6% average annual rate for the Yaqui Valley and 2.1% for Pinal County. Because Average Yields for ten crops assigns equal weight to each one of the crops included, yields for cotton and wheat were also included in the analysis. The results show that Arizona and Pinal County have better yields for wheat and that these yields increase at 2.6% and 3.4% average annual rate respectively, compared to 2.2% and 2.0% for Sonora and the Yaqui Valley. On the other hand, yields for cotton seem to be better for Sonora and the Yaqui Valley, with 4.2% and 5.5% average annual rate increase respectively, compared to 1.7% and 2.3% for Arizona and Pinal County.

The production of improved seeds in Sonora has increased significantly from 1969 to 1978. Important crops for which production of improved seeds has increased substantially are soy beans, with 268% average annual rate increased production; wheat, 50%; safflower, 46%; and cotton, 33%. Some of the improved seeds produced in Sonora are exported to national and international markets. However, the use of improved seeds by Sonoran farmers seems to be a generalized practice.

Fertilizer consumption at the state level increased at a 3% average annual rate for 1975-1978. Fertilization of crops is a common practice among Yaqui Valley farmers, and fertilizer is used on more than 70% of the land used for cultivation. Although there were some differences in the levels of use of inputs between the Yaqui Valley and Pinal County, nonetheless the same inputs were used in both regions.

Sonora, in 1978, had 98.7% of its land using agricultural machinery. The number of tractors placed Sonora second only to the state of Sinaloa. The Yaqui Valley is considered to be totally mechanized.

There seems to be a growing trend toward greater use of fertilizers, herbicides, and mechanized farm operations. These conclusions resulted from a survey of farmers from the Yaqui Valley. Some substitution of inputs, especially labor and capital, seemed to exist by the way farmers switched from labor to herbicides, or from labor to machinery. The extension service program which is offered by private as well as official institutions seemed to affect farmers' use of production inputs. The harvesting of cotton in the Yaqui Valley is done through mechanical as well as labor harvesting. Labor is imported to the Valley mostly from Mexican southern states. Mechanical harvesting is carried out, for the most part, by custom hiring. The harvesting of cotton in the Yaqui Valley takes place during the rainy season; thus the availability of harvesters and the rain factor account for farmers' using either mechanical harvesters or labor or a combination of both to harvest cotton.

The future trend of governmental agricultural policies will probably be oriented more towards the rain-fed areas of the south. Policies of the present administration are intended for the development of these areas; these policies are aimed at the production of staple which the country had been importing. Research on agricultural production has been poor in the rain-fed areas, and the current trend is to improve this situation. The trend in education also is oriented toward the poor farmers, and each year the Ministry of Public Education opens new schools in rural areas which prepare middle-level agricultural technicians. It seems that the irrigation areas of the country will continue to make extensive use of modern technology and continue to produce crops for export and industrial use.

## APPENDIX A

### Results from Regressions

The significance analysis performed on the simple linear regressions with respect to time was based on the t-statistic performed on the coefficient of the slope. Each result presents the coefficients of the linear trend, the regression coefficient r, an upper and lower limit to the slope within the 0.975 level of confidence, and the significance of the slope within $\alpha$ level of confidence. When testing the significance of the slope the hypotheses were $H_o:\beta_o=0$, and $H_1:\beta_o=b$. Where $\beta_o$ is the true value of the slope, b is the calculated value of the slope, $H_o$ is the null hypothesis, and $H_1$ the alternative hypothesis. The null hypothesis $H_o$ was rejected whenever $t_C$ was greater than $t_T$. Where $t_C$ is the calculated t-statistic, and $t_T$ is the t-statistic obtained from a table with n-2 degrees of freedom and $\alpha$ level of confidence.

1. - M1 = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance $\alpha$ |
|---|---|---|---|---|---|
| Y-Intercept | -6068.56 | | | | |
| Slope (b) | 3.13 | 12.69 | > | 2.718 | 99% |
| R | 0.9675 | | | | |
| b-Lower limit | 2.589 | | | | |
| b-Upper limit | 3.675 | | | | |

2. - Ul = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -4889.1600 | | | | |
| Slope (b) | 2.5300 | 12.7200 | > | 2.7180 | 99% |
| R | 0.9676 | | | | |
| b-Lower limit | 2.0950 | | | | |
| b-Upper limit | 2.9710 | | | | |

3. - M2 = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | 988.7800 | | | | |
| Slope (b) | -0.4500 | -2.364 | > | 2.201 | 95% |
| R | -0.5800 | | | | |
| b-Lower limit | -0.8700 | | | | |
| b-Upper limit | -0.0300 | | | | |

4. - U2 = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -2951.5300 | | | | |
| Slope (b) | 1.5500 | 8.150 | > | 2.718 | 99% |
| R | 0.9263 | | | | |
| b-Lower limit | 1.1300 | | | | |
| b-Upper limit | 1.9700 | | | | |

5. - M3 = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -1204.5500 | | | | |
| Slope (b) | 0.6600 | 11.653 | > | 2.624 | 99% |
| R | 0.9521 | | | | |
| b-Lower limit | 0.5400 | | | | |
| b-Upper limit | 0.7800 | | | | |

6. - U3 = F(Year)

| Item | Coefficient | T-Statistics Calc. | Tab. | Significance |
|---|---|---|---|---|
| Y-Intercept | -3493.1400 | | | |
| Slope (b) | 1.8200 | 10.819 | > 2.624 | 99% |
| R | 0.9451 | | | |
| b-Lower limit | 1.4600 | | | |
| b-Upper limit | 2.1900 | | | |

7. - LPM = F(Year)

| Item | Coefficient | T-Statistics Calc. | Tab. | Significance |
|---|---|---|---|---|
| Y-Intercept | -4778.6600 | | | |
| Slope (b) | 2.4800 | 10.337 | > 2.718 | 99% |
| R | 0.9522 | | | |
| b-Lower limit | 1.9500 | | | |
| b-Upper limit | 3.0000 | | | |

8. - LPU = F(Year)

| Item | Coefficient | T-Statistics Calc. | Tab. | Significance |
|---|---|---|---|---|
| Y-Intercept | -552.1400 | | | |
| Slope (b) | 0.3300 | 0.973 | > 0.876 | 80% |
| R | 0.2815 | | | < 80% |
| b-Lower limit | -0.4200 | | | |
| b-Upper limit | 1.0800 | | | |

Note: Value of regression coefficient insignificant at 80% level.

9. - M4 = F(Year)

| Item | Coefficient | T-Statistics Calc. | Tab. | Significance |
|---|---|---|---|---|
| Y-Intercept | -1896.4600 | | | |
| Slope (b) | 1.0100 | 39.90 | > 2.65 | 99% |
| R | 0.9959 | | | |
| b-Lower limit | 0.9587 | | | |
| b-Upper limit | 1.0700 | | | |

10. - U4 = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | 7690.1000 | | | | |
| Slope (b) | -3.8500 | -22.200 | > | 2.650 | 99% |
| R | -0.9871 | | | | |
| b-Lower limit | -4.230 | | | | |
| b-Upper limit | -3.4800 | | | | |

11. - LBPM = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -3678.6600 | | | | |
| Slope (b) | 1.9200 | 8.680 | > | 2.718 | 99% |
| R | 0.9342 | | | | |
| b-Lower limit | 1.4300 | | | | |
| b-Upper limit | 2.400 | | | | |

12. - LBPU = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -15370.8900 | | | | |
| Slope (b) | 7.8500 | 18.918 | > | 2.718 | 99% |
| R | 0.9850 | | | | |
| b-Lower limit | 6.9400 | | | | |
| b-Upper limit | 8.7700 | | | | |

13. - M5 = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -20078.6400 | | | | |
| Slope (b) | 10.2400 | 15.743 | > | 2.650 | 99% |
| R | 0.9748 | | | | |
| b-Lower limit | 8.8400 | | | | |
| b-Upper limit | 11.6500 | | | | |

14. - U5 = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -8572.4000 | | | | |
| Slope (b) | 4.4000 | 14.250 | > | 2.650 | 99% |
| R | 0.9694 | | | | |
| b-Lower limit | 3.7300 | | | | |
| b-Upper limit | 5.0700 | | | | |

15. - (Fert./hectare) = F(Year) -- Mexico

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -18926.5300 | | | | |
| Slope (b) | 9.6600 | 15.500 | > | 2.650 | 99% |
| R | 0.9740 | | | | |
| b-Lower limit | 8.3100 | | | | |
| b-Upper limit | 11.0100 | | | | |

16. - (Fert./hectare) = F(Year) -- United States

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -5340.8700 | | | | |
| Slope (b) | 2.7600 | 7.320 | > | 2.650 | 99% |
| R | 0.8970 | | | | |
| b-Lower limit | 1.9500 | | | | |
| b-Upper limit | 3.5800 | | | | |

17. - FPM = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | 11633.3900 | | | | |
| Slope (b) | -5.8500 | -7.680 | > | 2.764 | 99% |
| R | -0.9247 | | | | |
| b-Lower limit | -7.5500 | | | | |
| b-Upper limit | -4.1500 | | | | |

18. - FPU = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | 2809.8400 | | | | |
| Slope (b) | -1.3700 | -3.420 | > | 2.764 | 99% |
| R | -0.7342 | | | | |
| b-Lower limit | -2.2700 | | | | |
| b-Upper limit | -0.4800 | | | | |

19. - M6 = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -8160.7100 | | | | |
| Slope (b) | 4.1900 | 26.560 | > | 2.896 | 99% |
| R | 0.9944 | | | | |
| b-Lower limit | 3.8300 | | | | |
| b-Upper limit | 4.5600 | | | | |

20. - U6 = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | 1800.2200 | | | | |
| Slope (b) | -0.8600 | -2.746 | > | 2.306 | 97.5% |
| R | -0.6966 | | | | |
| b-Lower limit | -1.5900 | | | | |
| b-Upper limit | -0.1400 | | | | |

21. - (Tractors/hectare) = F(Year) -- Mexico

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -6955.1600 | | | | |
| Slope (b) | 3.5800 | 16.770 | > | 2.896 | 99% |
| R | 0.9861 | | | | |
| b-Lower limit | 3.1000 | | | | |
| b-Upper limit | 4.0700 | | | | |

22. - (Tractors/hectare) = F(Year) -- United States

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | 4502.2900 | | | | |
| Slope (b) | -2.2400 | -6.630 | > | 2.896 | 99% |
| R | -0.9198 | | | | |
| b-Lower limit | -3.0100 | | | | |
| b-Upper limit | -1.4600 | | | | |

23. - MPM = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | 1549.1600 | | | | |
| Slope (b) | -0.7400 | -3.340 | > | 2.896 | 99% |
| R | -0.7636 | | | | |
| b-Lower limit | -1.2400 | | | | |
| b-Upper limit | -0.2300 | | | | |

24. - MPU = F(Year)

| Item | Coefficient | T-Statistics Calc. | | Tab. | Significance |
|---|---|---|---|---|---|
| Y-Intercept | -7605.4800 | | | | |
| Slope (b) | 3.9100 | 8.880 | > | 2.896 | 99% |
| R | 0.9529 | | | | |
| b-Lower limit | 2.8960 | | | | |
| b-Upper limit | 4.9300 | | | | |

## Calculation of Standard Deviations

The calculation of the standard deviation for most indices used in this study was done from the residuals obtained from the regression performed, using the following formula:

$$\text{standard deviation of } [(x_i - \tilde{x}_i)/(\tilde{x}_i)] \cdot 100$$

where $x_i$ are the individual observed values, $\tilde{x}_i$ are the calculated regression values of the corresponding $x_i$, and $(x_i - \tilde{x}_i)$ are the residuals.

This method was chosen over the standard method because it offers a correction for the trend of the observed data and makes the standard deviation between two indices more suitable for comparison.

## Population Data, National Level

Tables A.1 through A.3 present data on population and labor force for Mexico and the United States.

Table A.1. Total Population for Mexico and the United States, 1960-1979

| | Mexico (x 1000) | % change | U.S. (x 1000) | % change |
|---|---|---|---|---|
| 1960 | 36 369 | | 180 671 | |
| 1965 | 42 859 | 3.60/yr. | 194 303 | 1.51/yr. |
| 1970 | 50 313 | 3.48/yr. | 204 879 | 1.10/yr. |
| 1975 | 59 204 | 3.50/yr. | 213 540 | 0.85/yr. |
| 1976 | 61 196 | 3.30 | 215 120 | 0.74 |
| 1977 | 62 291 | 3.42 | 216 827 | 0.79 |
| 1978 | 65 442 | 3.40 | 218 522 | 0.78 |
| 1979 | 67 676 | 3.41 | 220 286 | 0.81 |
| MEAN | | 3.45 | | 0.94 |
| STD. DEV. | | 0.094 | | 0.278 |

Source: F.A.O., Production Yearbook, Vol. 29, 1975; Vol. 30, 1976; Vol. 33, 1979

Table A.2. Agricultural Population for Mexico and the United States, 1960-1979

| | Mexico (x 1000) | % change | U.S. (x 1000) | % change |
|---|---|---|---|---|
| 1960 | 20 041 | | 11 894 | |
| 1965 | 21 541 | 1.50/yr. | 9 909 | -3.34/yr. |
| 1970 | 22 751 | 1.10/yr. | 7 525 | -4.81/yr. |
| 1975 | 23 960 | 1.06/yr. | 5 872 | -4.41/yr. |
| 1976 | 24 225 | 1.1 | 5 666 | -3.50 |
| 1977 | 24 464 | 1.0 | 5 382 | -5.01 |
| 1978 | 24 713 | 1.0 | 5 163 | -4.03 |
| 1978 | 24 968 | 1.0 | 4 958 | -4.00 |
| MEAN | | 1.11 | | -4.16 |
| STD. DEV. | | 0.178 | | 0.627 |

Source: F.A.O., Production Yearbook, Vol. 29, 1975; Vol. 30, 1976; Vol. 33. 1979.

Table A.3. Total Labor Force for Mexico and the United States, 1960-1979

| | Mexico (x 1000) | % change | U.S. (x 1000) | % change |
|---|---|---|---|---|
| 1960 | 10 992 | | 73 198 | |
| 1965 | 12 519 | 2.78.yr. | 79 412 | 1.70/yr. |
| 1970 | 14 487 | 3.14/yr. | 87 122 | 2.01/yr. |
| 1975 | 17 069 | 3.56/yr. | 94 470 | 1.70/yr. |
| 1976 | 17 663 | 3.48 | 95 798 | 1.41 |
| 1977 | 18 264 | 3.40 | 97 216 | 1.48 |
| 1978 | 18 886 | 3.40 | 98 548 | 1.37 |
| 1978 | 19 532 | 3.42 | 99 924 | 1.40 |
| MEAN | | 3.31 | | 1.58 |
| STD. DEV. | | 0.218 | | 0.234 |

Source: F.A.O., Production Yearbook, Vol. 29, 1975; Vol. 30, 1976; Vol. 33. 1979.

Some of the values for agricultural labor for the United States, the values in parentheses in Table 9, were calculated in the following way: the values for total labor force and labor force in agriculture, silviculture, and forestry were available from the International Labor Organization of the United Nations (I.L.O.) from 1965 to 1977. The percentage of labor engaged in agriculture was obtained from these data and used in Table 9.

# APPENDIX B

## Average Yield Indices

The index of yield per land area was calculated using the yields for ten crops for the state of Sonora, and ten crops for the state of Arizona. The crops included for Sonora were alfalfa, sesame, safflower, barley, flax, corn, sorghum, soy beans, wheat, and cotton. For Arizona, the crops included were cotton, alfalfa, wheat, barley, corn, sorghum, safflower, other hay, sugar beets, and lettuce. An index of yield was calculated for each crop, taking the average yield of 1969-1971 as the base. Then, for each year, the yield index was summed and divided by the number of crops so that we got then the average yield index of ten crops for that year in particular. Tables B.1 and B.2 present these figures for Sonora and Arizona respectively.

The average yield index for the local level was calculated in the same way as the average yield index for the state level. Ten crops were used for the Yaqui Valley, and nine for Pinal County. Tables B.3 and B.4 present these figures.

Table B.1 Yield and Average Yield Indices for Selected Crops, Sonora, 1969-1980

| Year | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | Avg. Yield |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 104 | 88 | 93 | 93 | 93 | 99 | 94 | 62 | 98 | 97 | 92.1 |
| 1970 | 100 | 106 | 109 | 99 | 98 | 96 | 100 | 119 | 101 | 101 | 102.9 |
| 1971 | 97 | 106 | 98 | 108 | 109 | 105 | 106 | 119 | 101 | 101 | 105.0 |
| 1972 | 100 | 106 | 88 | 93 | 93 | 96 | 110 | 119 | 93 | 97 | 99.5 |
| 1973 | 93 | 88 | 103 | 96 | 109 | 86 | 92 | 124 | 114 | 134 | 103.9 |
| 1974 | 89 | 106 | 93 | 105 | 109 | 86 | 81 | 130 | 114 | 126 | 103.9 |
| 1975 | 94 | 88 | 103 | 105 | 120 | 99 | 85 | 136 | 130 | 122 | 108.2 |
| 1976 | 81 | 106 | 103 | 96 | 98 | 93 | 69 | 124 | 119 | 146 | 103.5 |
| 1977 | 78 | 124 | 103 | 96 | 109 | 62 | 71 | 108 | 104 | 134 | 98.9 |
| 1978 | 99 | 70 | 93 | 105 | 93 | 86 | 65 | 113 | 114 | 138 | 97.6 |
| 1979 | 74 | 88 | 78 | 96 | 104 | 121 | 77 | 108 | 130 | 138 | 101.4 |
| 1980 | 89 | 124 | 88 | 105 | 98 | 105 | 71 | 124 | 117 | 142 | 106.3 |

Source: Index for each crop was calculated from yield per hectare data from SARH, DGEA, Anuario Estadistico de la Produccion Agricola de los Estados Unidos Mexicanos, various issues.

Note: S1: alfalfa, S2: sesame, S3: safflower, S4: barley, S5: flax, S6: corn, S7: sorghum, S8: soy beans, S9: wheat, S10: cotton.

Table B.2. Yield and Average Yield Indices for Selected Crops, Arizona, 1969-1980

| Year | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | Avg. Index |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 109 | 94 | 93 | 96 | 98 | 103 | 88 | 101 | 101 | 102 | 98.5 |
| 1970 | 96 | 104 | 104 | 103 | 87 | 96 | 100 | 101 | 80 | 89 | 96.0 |
| 1971 | 95 | 102 | 102 | 100 | 116 | 100 | 112 | 97 | 119 | 109 | 105.2 |
| 1972 | 112 | 102 | 101 | 96 | 128 | 107 | 96 | 101 | 130 | 93 | 106.6 |
| 1973 | 113 | 109 | 102 | 102 | 116 | 99 | 78 | 101 | 122 | 89 | 103.1 |
| 1974 | 131 | 108 | 98 | 96 | 123 | 107 | 94 | 97 | 133 | 112 | 109.9 |
| 1975 | 110 | 113 | 106 | 102 | 120 | 94 | 98 | 97 | 120 | 120 | 108.0 |
| 1976 | 128 | 121 | 113 | 103 | 217 | 100 | -- | 110 | 129 | 128 | 127.7 |
| 1977 | 109 | 113 | 108 | 103 | 362 | 110 | 82 | 106 | 125 | 120 | 133.8 |
| 1978 | 105 | 109 | 106 | 96 | 416 | 107 | 100 | 97 | 115 | 113 | 136.4 |
| 1979 | 116 | 111 | 115 | 102 | 416 | 98 | 76 | 101 | 108 | 83 | 132.6 |
| 1980 | 101 | 101 | 121 | 107 | 362 | 103 | 79 | 154 | 128 | 126 | 142.2 |

Source: 1980 Arizona Agricultural Statistics, Az. Crop & Livestock Reporting Service, Bulletin S-16, April, 1981.

Note: A1: cotton, A2: alfalfa, A3: wheat, A4: barley, A5: corn, A6: sorghum, A7: safflower, A8: other hay, A9: sugar beets, A10: lettuce.

Table B.3. Yield and Average Yield Indices for Selected Crops, Irrigation District No. 41, Yaqui Valley, Sonora, 1969-1980

| Year | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 | Y8 | Y9 | Y10 | Avg. Yield |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 105.0 | 95.4 | 89.5 | 92.8 | 101.0 | 85.6 | 84.4 | 89.2 | 98.8 | 85.6 | 92.7 |
| 1970 | 100.3 | 96.9 | 115.3 | 99.0 | 95.2 | 103.6 | 106.0 | 103.3 | 97.5 | 106.8 | 102.4 |
| 1971 | 97.7 | 107.7 | 95.2 | 108.2 | 103.8 | 110.7 | 109.7 | 107.6 | 103.7 | 107.5 | 104.9 |
| 1972 | 65.6 | 113.4 | 92.9 | 117.5 | 85.9 | 92.4 | 102.4 | 105.7 | 92.5 | 98.2 | 96.6 |
| 1973 | 67.0 | 100.0 | 91.8 | 123.7 | 88.9 | 88.8 | 116.6 | 110.3 | 108.7 | 123.2 | 101.9 |
| 1974 | 32.4 | 131.0 | 101.7 | 140.2 | 104.7 | 101.0 | 89.7 | 119.2 | 117.2 | 128.6 | 106.6 |
| 1975 | 34.8 | 110.6 | 98.2 | 57.6 | 101.2 | 123.1 | 101.7 | 124.2 | 132.3 | 126.0 | 101.0 |
| 1976 | 64.0 | 90.6 | 82.1 | 47.1 | 89.0 | 125.0 | 104.2 | 112.7 | 122.8 | 127.9 | 96.5 |
| 1977 | 70.1 | 117.9 | 103.2 | 61.8 | 93.4 | 107.4 | 99.8 | 95.2 | 105.7 | 135.1 | 99.0 |
| 1978 | 63.7 | 130.5 | 82.0 | -- | 79.6 | 109.4 | 81.7 | 101.5 | 112.0 | 144.6 | 100.6 |
| 1979 | 70.1 | 64.8 | 72.3 | -- | 82.2 | 146.0 | 104.3 | 97.4 | 126.7 | 116.9 | 97.8 |
| 1980 | 80.2 | 110.6 | 90.8 | 116.5 | 81.2 | 146.0 | 87.6 | 115.0 | 115.3 | 141.4 | 108.5 |

Source: SARH, unpublished data.

Note: Y1: alfalfa, Y2: sesame, Y3: safflower, Y4: barley, Y5: flax, Y6: corn, Y7: sorghum, Y8: soy beans, Y9: wheat, Y10: cotton.

Table B.4. Yield and Average Yield Indices for Selected Crops, Pinal County, Arizona, 1969-1980

| Year | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | Avg. Index |
|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 105.6 | 97.3 | 98.4 | 88.0 | 97.0 | 111.9 | 99.5 | 125.3 | 106.6 | 103.3 |
| 1970 | 100.7 | 101.4 | 98.4 | 108.4 | 106.5 | 86.6 | 89.9 | 74.7 | 92.4 | 95.4 |
| 1971 | 93.6 | 101.4 | 103.3 | 103.6 | 96.7 | 101.5 | 110.6 | 100.0 | 101.0 | 101.3 |
| 1972 | 110.3 | 95.3 | 103.3 | 103.6 | 93.8 | 91.6 | 86.3 | 125.9 | 89.0 | 99.9 |
| 1973 | 114.4 | 99.3 | 123.0 | 106.8 | 95.3 | 91.1 | 71.1 | 117.3 | 95.2 | 101.5 |
| 1974 | 120.4 | 103.4 | 137.7 | 98.8 | 83.5 | 119.5 | 89.9 | 135.8 | 101.0 | 110.0 |
| 1975 | 87.0 | 113.5 | 123.0 | 111.6 | 103.6 | 104.0 | 99.5 | 121.6 | 112.9 | 108.5 |
| 1976 | 117.6 | 131.8 | 123.0 | 118.0 | 106.5 | 122.3 | -- | 127.8 | 139.2 | 123.3 |
| 1977 | 111.5 | 131.8 | 123.0 | 111.6 | 105.1 | 121.7 | 79.9 | 116.0 | 118.6 | 113.2 |
| 1978 | 96.8 | 107.4 | 98.4 | 110.8 | 91.3 | 120.0 | 98.3 | 124.1 | 119.2 | 107.4 |
| 1979 | 112.7 | 125.7 | 113.1 | 117.4 | 104.8 | 108.2 | 69.1 | 109.9 | 87.8 | 105.4 |
| 1980 | 118.5 | 129.7 | 182.0 | 122.0 | 110.3 | 110.8 | 84.7 | 135.8 | 131.7 | 125.0 |

Source: 1980 Arizona Agricultural Statistics, Arizona Crop & Livestock Reporting Service, Bulletin S-16, April 1981.

Note: P1: cotton, P2: alfalfa, P3: other hay, P4: wheat, P5: barley, P6: sorghum, P7: safflower, P8: sugar beet P9: lettuce.

## Population Data, Sonora

Table B.5 presents data on population for the state of Sonora, from the 1960 and 1970 censuses.

Table B.5. Population Data for Sonora, 1960 and 1970

| | 1960 | 1970 |
|---|---|---|
| Total Population | 783,378 | 1,098,720 |
| Economically Active Population (Male) | 207,972 | 233,650 |
| EAP, Males, in Agriculture | 118,429 | 102,940 |
| EAP, Female | 43,033 | 50,549 |
| EAP, Female in Agriculture | 15,984 | 6,437 |

Source: S.P.P., Coordinacion General del Sistema Nacional de Informacion, Mexico, 1979.

## Data on Improved Seeds and Fertilizers

Tables B.6 to B.8 were used to calculate the results that are presented on Table 28 of this paper. The figures in Table B.6 were divided by the figures in Table B.7, for each crop, for each year; and this gave us the results in the first column of Table 28. The second column was calculated using the data in Tables B.6 and B.7.

Table B.6. Hectares (x 1000) in Which Improved Seeds Were Used, for Selected Crops, Irrigation District No. 41, Yaqui Valley, Sonora

| Crop | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|
| Soy Beans | 59.8 | 107.0 | 72.8 | 83.1 | 46.9 | 12.0 | 32.0 | 81.6 | 40.9 |
| Sesame | 1.3 | 1.7 | 0.9 | 0.6 | 3.0 | 3.9 | 15.9 | 38.1 | 13.2 |
| Corn | 7.0 | 15.0 | 8.1 | 1.2 | 0.5 | 4.1 | 0.2 | 14.1 | 2.8 |
| Alfalfa | 3.1 | 3.0 | 2.7 | 2.2 | 2.2 | 2.3 | 3.8 | 3.7 | 3.8 |
| Sorghum | 8.4 | 12.6 | 4.3 | 7.8 | 6.8 | n.a. | 3.2 | 5.0 | 7.7 |
| Cotton | 62.6 | 37.4 | 49.6 | 5.5 | 6.5 | n.a. | 26.0 | 40.3 | 34.5 |
| Wheat | n.a. | 109.2 | 124.2 | 136.9 | 165.1 | n.a. | 111.3 | 69.3 | 126.5 |
| Safflower | n.a. | 21.8 | 14.2 | 38.5 | 16.4 | n.a. | 56.1 | 60.2 | 22.3 |
| Flax | n.a. | 2.5 | 0.8 | 6.3 | 2.3 | n.a. | 2.5 | 2.2 | 0.7 |

Source: SARH, DGEA, Informe Estadistico, various issues.
n.a. = Not available.

Table B.7. Hectares (x 1000) in Which Fertilizer Was Used, for Selected Crops, Irrigation District No. 41, Yaqui Valley, Sonora

| Crop | 1965 | 1966 | 1967 | 1968 | 1970 | 1971 | 1973 | 1974 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 128.4 | 75.4 | 125.4 | 102.6 | 130.0 | 83.3 | 103.3 | 118.6 | 111.3 | 70.0 | 130.0 |
| Safflower | 0.1 | 11.2 | 5.4 | 6.4 | 9.7 | 28.6 | 19.3 | 12.7 | 55.0 | 59.0 | 21.8 |
| Flax | 0.1 | 1.4 | n.a. | 1.0 | 2.2 | 6.9 | 2.2 | 0.7 | 2.4 | 2.1 | 0.6 |
| Sorghum | 1.8 | 7.1 | 3.2 | 5.9 | 7.0 | 6.4 | 9.9 | 3.4 | 3.0 | 5.0 | 7.7 |
| Cotton | 51.4 | 63.5 | 46.6 | 72.0 | 33.0 | 49.9 | 36.3 | 48.6 | 26.0 | 40.3 | 34.5 |
| Alfalfa | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | 1.9 | 3.0 | 3.1 |
| Soy Beans | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | 30.4 | 75.1 | 37.2 |
| Sesame | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | 15.1 | 35.9 | 15.3 |
| Corn | 36.5 | 9.9 | 35.0 | 19.6 | 15.1 | 0.3 | 13.4 | 6.6 | 0.2 | 14.1 | 2.8 |

Source: SARH, DGEA, Informe Estadistico, various issues.
n.a.: Not available.
Note: Data for 1969, 1972, 1975, 1976, 1977 not available.

Table B.8. Harvested Area (x 1000 ha) for Selected Crops, Irrigation District No. 41, Yaqui Valley, Sonora, 1965-1980

| Crop | 1965 | 1966 | 1967 | 1968 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cotton | 53.2 | 64.8 | 47.5 | 73.6 | 34.1 | 51.2 | 62.6 | 37.6 | 49.6 | 5.5 | 6.4 | 35.8 | 26.0 | 40.3 | 34.5 |
| Alfalfa | 3.2 | 2.2 | 2.2 | 1.8 | 1.9 | 3.1 | 2.8 | 2.5 | 2.4 | 2.1 | 2.1 | 2.3 | 3.8 | 3.7 | 3.8 |
| Sesame | 4.0 | 2.6 | 11.2 | 9.1 | 15.4 | 3.2 | 1.9 | 1.7 | 0.9 | 0.6 | 2.6 | 4.2 | 12.7 | 38.1 | 13.2 |
| Safflower | 0.1 | 12.9 | 6.0 | 5.2 | 10.8 | 32.6 | 20.9 | 21.8 | 14.2 | 38.5 | 16.4 | 33.6 | 56.0 | 60.2 | 22.3 |
| Flax | 0.1 | 1.5 | 1.1 | 1.1 | 2.4 | 7.6 | 1.0 | 2.5 | 0.8 | 6.3 | 2.3 | 4.0 | 2.5 | 2.1 | 0.7 |
| Corn | 54.0 | 11.0 | 41.6 | 21.8 | 17.9 | 10.0 | 7.0 | 15.0 | 6.9 | 17.0 | 0.5 | 4.1 | 0.2 | 14.1 | 2.9 |
| Sorghum | 2.4 | 8.9 | 4.2 | 7.5 | 8.8 | 8.0 | 8.4 | 12.6 | 4.3 | 7.8 | 6.7 | 3.6 | 3.2 | 5.0 | 7.7 |
| Soy Beans | 17.2 | 28.5 | 34.7 | 74.4 | 76.0 | 56.1 | 59.8 | 107.0 | 72.8 | 83.1 | 46.9 | 12.0 | 30.4 | 81.6 | 40.9 |
| Wheat | 135.2 | 85.7 | 136.7 | 108.9 | 136.7 | 89.8 | 98.9 | 109.2 | 124.8 | 136.8 | 165.1 | 115.4 | 110.4 | 70.0 | 130.0 |

Source: SARH, DGEA, Informe Estadistico, various issues.

## APPENDIX C

### Results of Survey

The answers given to each question of the questionnaire are presented below. A copy of the original questionnaire is also included.

Part I

1. Do you use herbicides in wheat:

    Yes: 99%
    No: 1%

2. Do you use herbicides in cotton?

    Yes: 88%
    No: 12%

3. In the last ten years do you consider that the use of herbicides in wheat has:

    Increased: 51%
    Decreased: 2%
    Constant: 47%

4. In the last ten years do you consider that the use of herbicides in cotton has:

    Increased: 50%
    Decreased: 0
    Constant: 50%

5. What do you think are the reasons for the increase or decrease in the use of herbicides, in the last ten years:

    a. Low cost of herbicides with respect to labor: 55 answers
    b. Increased weeds: 44 answers
    c. High cost of labor: 31 answers

6. How do you apply your herbicides?

   a. Surface (using tractor and pump) and by air: 100 answers
   b. Surface only: 11 answers
   c. By air only: 5 answers

7. If you do not use herbicides, how do you control weeds?

   a. Use labor: 78 answers
   b. Use labor and mechanically: 53 answers
   c. Mechanically only: 2 answers

8. Omitted.

Part II

9. Do you use fertilizer in wheat?

   Yes: 100%
   No: 0

10. Do you use fertilizer in cotton?

   Yes: 100%
   No: 0

11. In the last ten years, do you consider that the use of fertilizer in wheat has:

   Increased: 61%
   Decreased: 1%
   Constant: 38%

12. In the last ten years, do you consider that the use of fertilizer in cotton has:

   Increased: 60%
   Decreased: 1%
   Constant: 39%

13. What do you think are the reasons for the increase or decrease in the use of fertilizers, in the last ten years?

   a. Because of the increases in production: 79 answers
   b. Recommendations made by the extension service: 65 answers
   c. Because of poor soils due to continued exploitation: 23 answers

Part III

14. In which cultural practices do you not make use of machinery?

   a. Manual weeding: 87 answers
   b. Irrigation: 50 answers

15. Do you consider that, in the last ten years, the use of machinery has increased for farm operations?

   Yes: 100%
   No: 0

16. What do you think are the reasons for the increase or decrease in the use of machinery?

   a. Efficiency and fast way to do the job: 41 answers
   b. Increase in arable land: 41 answers
   c. Government's farm mechanization program: 14 answers
   d. Less expensive than using labor: 13 answers

17. In the last ten years, do you consider that the use of machinery with respect to labor has:

   Increased: 96%
   Decreased: 0
   Constant: 4%

Part IV

18. In the harvesting of cotton, in what percentage of your land do you use machines, and in what percentage do you use labor?

   [See Table 35 for answers]

19. If you use more mechanical harvesting, state your reasons for not employing labor.

   a. Labor does a bad job: 52 answers
   b. Scarcity of labor: 48 answers
   c. Cost of labor is higher: 39 answers
   d. Problems in setting the price per kilo: 34 answers
   e. Problems to transport labor: 32 answers

20. If you use mechanical harvesting, the quality of cotton:

| | |
|---|---|
| Decreases very much: | 4% |
| Decreases little: | 46% |
| Decrease is normal: | 15% |
| No decrease: | 35% |

21. If you use mechanical harvesting, the quantity of cotton:

| | |
|---|---|
| Decreases very much: | 4% |
| Decreases little: | 28% |
| Same as with labor: | 57% |
| Increases: | 11% |

22. If you use more labor to pick cotton, state your reasons for not using more mechanical harvesting.

| | | |
|---|---|---|
| a. | My land is ejidal and I have to create jobs: | 13 answers |
| b. | Mechanical harvesting decreases the quantity of cotton: | 6 answers |

23. In picking cotton, if you use part mechanical harvesting and part labor, what are your reasons for doing so?

| | | |
|---|---|---|
| a. | Rain, or wet fields: | 19 answers |
| b. | People pick up what machines leave: | 17 answers |
| c. | Use labor when machines break down: | 13 answers |
| d. | Unleveled fields: | 6 answers |
| e. | Scarcity of labor: | 5 answers |

24. Are there years when you use more labor than machinery to pick cotton?

| | |
|---|---|
| Yes: | 69% |
| No: | 31% |

25. Why?

| | | |
|---|---|---|
| a. | Because there are not enough machines available: | 25 answers |
| b. | Because of rains: | 22 answers |
| c. | To create jobs: | 12 answers |

26. Are there years when you use more mechanical harvesting than labor to pick cotton?

| | |
|---|---|
| Yes: | 81% |
| No: | 19% |

27. Why?

    a. When there are mechanic harvesters available: 16 answers
    b. I only use labor when machines cannot get into the field because of rains: 15 answers
    c. I have less trouble using mechanical harvesting: 14 answers
    d. Machines are fast and effective: 13 answers

28. Any comment with respect to cotton harvesting in the Yaqui Valley?

    a. It should be 100% mechanized: 33 answers
    b. There should be a balance between labor and machines: 15 answers
    c. There should be regulation on the harvest: 15 answers
    d. Using labor, the discounts we get at the gin are higher; moreover, the harvest with labor is costly: 11 answers

## Sample Questionnaire

### ENCUESTA SOBRE PRODUCCION DE TRIGO Y ALGODON

Esta encuesta es anónima. Los datos generados serán evaluados en forma global; y serán utilizados en una tésis profesional.

1. Utiliza Ud. herbicadas?

   En el cultivo de trigo: ( ) Si ( ) No.
   En el cultivo de algodón: ( ) Si ( ) No.

2. En los últimos 10 años considera Ud. que el uso de herbicidas ha:

   En el cultivo de trigo: ( ) aumentado ( ) disminuido ( ) constante
   En el algodón: ( ) aumentado ( ) disminuido ( ) constante

3. Cual(es) considera Ud. que sean las razones por las cuales el uso de herbicidas haya aumentado o disminuido en los últimos 10 años?

   ( ) Alto costo de mano de obra.
   ( ) Bajo costo de mano de obra, con respecto a herbicidas.
   ( ) Alto costo de herbicidas.
   ( ) Bajo costo de herbicidas con respecto a mano de obra.
   ( ) Otro (especifique) ______________________________
   ______________________________________________.

4. En que forma aplica Ud. sus herbicidas? ______________________
   ______________________________________________.

5. En caso de no utilizar herbicidas, en que forma deshierba? ________
   ______________________________________________.

 a. En caso de utilizar <u>mano de obra</u>, cuantas horas utiliza por hectarea? (Número aproximado de jornales.) ______________________.

6. Utiliza Ud. fertilizantes?

   En el trigo: ( ) Si ( ) No.
   En algodón: ( ) Si ( ) No.

7. En los últimos 10 años, considera Ud. que el uso de fertilizantes ha:

   En trigo: ( ) aumentado ( ) disminuido ( ) permanecido constante
   En algodón: ( ) aumentado ( ) disminuido ( ) permanecido constante

8. Cuales cree Ud. que hayan sido las razones por las cuales el use de fertilizantes haya aumentado o disminuido?

( ) El bajo precio de estos (relativo)
( ) El alto precio de estos
( ) Por recomendaciones de técnicos
( ) Por los aumentos en producción (ventajas).
( ) Otro (especifique) ______________________________
______________________________________________.

9. En que labores de cultivo NO utiliza Ud. maquinaria? ____________
______________________________________________.

10. Considera Ud. que en los últimos 10 años ha incrementado el uso de maquinaria para labores en el campo?

( ) Si ( ) No.

11. A que cree Ud. que se deba el que haya aumentado o disminuido el uso de maquinaria en los últimos 10 años? ____________________
______________________________________________.

12. En los últimos 10 años cree Ud. que el uso de maquinaria con respecto a mano de obra ha:

( ) Aumentado
( ) Disminuido (se usa más mano de obra)
( ) Ha permanecido constante.

13. En la <u>pizca de algodón</u>, utiliza Ud.:

( ) Pizca mecánica en ___% de su tierra
( ) Pizca manual en ___% de su tierra.

a. En el caso de utilizar 100% pizca mecánica, por que no utiliza Ud. pizca manual?

( ) Problema de consequir pizcadores
( ) Problema de transportar pizcadores
( ) Problema de ponerse de acuerdo con el precio
( ) Pizcadores son descuidados en su trabajo
( ) Sale más caro que utilizar máquinas
( ) Otro (especifique) ______________________________
______________________________________________.

b. Si Ud. utiliza máquina, la calidad del algodón se merma:

( ) Mucho ( ) Poco ( ) Normal ( ) Nada.

c. Si Ud. utiliza máquina, la cantidad (rendimiento) del algodón:

( ) Baja mucho, ( ) Baja poco ( ) Igual que con pizcadores
( ) aumenta

15. En caso de utilizar 100% pizca manual, por que no utiliza pizca mecánica?

( ) Muy caro con respecto a mano de obra
( ) Merma mucho la calidad del algodón
( ) Merma mucho la cantidad de algódon cosechado
( ) Otro (especifique) ______________________________
______________________________________________.

16. Si Ud. utiliza parte de pizca mecánica y parte de pizca manual, cual considera Ud. que es la razón de hacer esto? ____________
______________________________________________.

17. Existen años (ciclos) en los que Ud. utilice más mano de obra que maquinaria para pizcar algodón?

( ) Si ( ) No.

a. Por que? ______________________________________
______________________________________________.

18. Existen años (ciclos) en los cuales utilice más máquinas que pizcadores?

( ) Si ( ) No.

a. Por que? ______________________________________
______________________________________________.

19. Comentario sobre la pizca del algodón en el Valle del Yaqui.

______________________________________________
______________________________________________
______________________________________________
______________________________________________.

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